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EDITORIAL

THIS is a noteworthy issue of the *British Journal of Anæsthesia*, for in it is to be found the preface to what will generally be accepted as an exciting serial. It is our intention to reprint in forthcoming numbers John Snow's lesser-known book *On the Inhalation of the Vapour of Ether* and so bring to the notice of our readers one of the masterpieces of medical literature. This book was recently republished in photostatic copy form in America but has not been available in this country for very many years past. The first instalment will appear in the January 1953 issue. As an introduction we publish in this number a complete biography of John Snow which appeared in *The Asclepiad* of 1886. It is certain that this volume is not generally available to our readers and the biography which we reproduce is of such human interest that we consider it a very fit preface to the reproduction in serial form of Snow's book.

The Asclepiad was a quarterly magazine produced by that remarkable man Sir Benjamin Ward Richardson. Sir Benjamin, who died in 1896, was a man of many parts and accomplishments. He not only edited but also wrote the

articles in his publication. According to his obituary in the *Lancet*,

> " the subject of anæsthetics attracted him greatly, and he approached it from the chemical and mechanical side as well as the clinical. He invented a double valve chloroform inhaler, many modifications of which have enjoyed considerable success. He made investigations into the reputed action of the smoke of the common " puff ball " (*Lycoperdon giganteum*) and discovered the application of ether spray for the local abolition of pain in minor operations. His chemical work was chiefly responsible for the introduction into British practice of the use of methylene bichloride as a general anæsthetic; while he also led the way in the employment of amyl chloride, amyl hydride, methylic ether, and butyl chloride among other bodies as producers of insensibility, and of nitrite of amyl as an anti-spasmodic. From certain of the experiments conducted to discover the chemical properties of these bodies Richardson happened upon the idea of the feasibility of producing painless death in the process of slaughtering animals, the practical result of which idea was the lethal chamber for the painless destruction of domestic animals."

Here is a pioneer whose work should certainly be better known to anæsthetists. In summarizing Sir Benjamin Ward Richardson's " busy and useful career " the *Lancet* writes as follows:

> " He was a wide, imaginative thinker. He was not only no specialist, but he found the ordinary boundaries of medicine too small for him, and extended his labours until he trespassed on the realms of the transcendental philosopher, of the educational novelist, of the temperance propagandist, of the sanitary inspector, and of the practical politician."

We hope that when the serialization of John Snow's work is complete we shall be able to make a reprint book available for purchase by those who are interested, in which we shall also include Sir Benjamin Ward Richardson's biography.

We are greatly indebted to Mr. Charles King, who has quietly been responsible for so many bright ideas in our speciality. It was his suggestion that we reintroduce to anæsthetists Snow's book on ether, by serialization in the *British Journal of Anæsthesia.*

The frontispiece of this issue of the Journal will no doubt prove of great interest to our readers. We have in the past produced a photograph of the eminent anæsthetist whose biography has been featured in the pages of the Journal. This picture, however, of the Anesthetists Travel Club taken in 1933 includes, besides Dr. Guedel, so many who will be friends to some of our readers and great names to others, that it seemed to us a good idea in this instance to depart from our usual custom. The picture does also remind us that in this country there is no comparable body of anæsthetists. It is true that in the activities of a Travel Club the emphasis is more on the social than the academic side. It might be true that anæsthetists are essentially academic minded, but few will aver that they are exclusively so. To be a success such a Club should include only those in whom the interest and attainments in both aspects are well matched.

The Royal Australasian College of Surgeons has announced the formation of a Faculty of Anæsthetists. This is indeed a big step forward in the development of the specialty among the English-speaking peoples. There is no doubt that we are expressing the sentiments of all our readers when we send this new academic body greetings and good wishes for a brilliant and inspiring future—*ad multos annos*.

Following the success of its Postgraduate Training Course in Anæsthesia in Copenhagen the World Health Organization has instituted a second centre in Paris. This is put in the first place under the supervision of Dr. Wesley Bourne of Montreal. Professor Moulonguet of Paris is the local Director. We wish the W.H.O. and Dr. Wesley Bourne every success in this further attempt to make good training facilities available for aspiring anæsthetists on the Continent.

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THE ESTIMATION AND COMPARISON OF HISTAMINE RELEASE BY MUSCLE RELAXANTS IN MAN

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IN READING the literature on muscle relaxants one is struck by the emphasis laid on histamine release. As each new muscle relaxant appears on the market, the manufacturers claim that it releases no histamine or that the amount it does release is less than that released by other relaxants.

Generalized histamine release in man causes bronchospasm or fall in blood-pressure or both. These manifestations can be of serious import in anæsthesia. They can, however, occur in cases where no muscle relaxant has been used. For example, both bronchospasm and fall in blood-pressure can follow intubation in light anæsthesia. It would be unjustifiable, therefore, to use either of these manifestations in the assessment of histamine release in man.

Blood-pressure fall, however, has been used to investigate histamine release in animals. MacIntosh and Paton (1949) have used cats in their investigations. They have found that, after blocking the autonomic ganglia with nicotine tartrate or tetraethylammonium iodide to prevent side effects, the injection of d-tubocurarine chloride or dimethyltubocurarine iodide releases histamine as shown by the fall in the cat's blood-pressure.

In man a simpler method is available. The intradermal injection of histamine or a substance which releases histamine produces a wheal and flare at the site of injection. The writer's attention was drawn to this manifestation by witnessing an anæsthetist inadvertently injecting d-tubocu-

rarine chloride into the skin instead of the vein. Within a minute a wheal and flare appeared at the site of injection. On consulting the literature it was found that Comroe and Dripps (1946) and Grob et al. (1947) had used this manifestation in their examination of histamine release by muscle relaxants in man. A similar technique has been used in this investigation.

METHOD

The muscle relaxants used were the commercial preparations of d-tubocurarine chloride, dimethyltubocurarine iodide, gallamine triethiodide, and decamethonium iodide. Fifteen milligrams of d-tubocurarine chloride were taken as equivalent in potency to 6 mg. of dimethyltubocurarine iodide, 120 mg. of gallamine triethiodide, and 3 mg. of decamethonium iodide. It was necessary, in order to obtain them in equal volumes, to dilute the preparations of d-tubocurarine chloride and decamethonium iodide with sterile water.

Sterile water was also used as the control. Two minims (0.13 ml.) of one of the muscle relaxants or the sterile water control were used in each patient.

At first it was decided to use Evans blue to measure the histamine production. Evans blue is a blue dye which when injected intravenously does not easily pass out of the blood-vessels.

Where histamine has been released, however, the permeability of the blood-vessels is increased and Evans blue passes out into the tissues at the site of histamine release where it is easily seen and the extent of its deposition can be measured.

The dye was used on the writer himself. In one forearm a sample of d-tubocurarine chloride was injected intradermally and in the other forearm an equal volume of sterile

water was injected, also intradermally, as a control. The skin was swabbed only lightly with spirit beforehand, as too vigorous cleansing results in an area of erythema which might interfere with the interpretations of the results. Eight millilitres of 0.24% Evans blue were injected intravenously.

Within one minute a wheal and flare developed at the site of the d-tubocurarine chloride injection and Evans blue was deposited in the wheal. At five minutes the wheal was at its maximum and filled with the dye. The area of the wheal and flare was traced out, transferred to graph paper and measured. In the case of the sterile water no wheal or flare developed but Evans blue was deposited in the wheal raised by the injection itself, and the dye was localized to this area, which was much smaller than that resulting in the arm in which d-tubocurarine chloride was injected. It was presumed to be due to histamine produced as a result of the local trauma inflicted.

About six hours later it was noticed that a delicate blue tinge was appearing in the face. This was at its maximum about fifteen hours later and took about six weeks to disappear. It was thought that this was due to too large a dose of Evans blue having been given or to the fact that a hot bath was taken shortly after the injection and that the resultant vasodilatation allowed the dye to pass out of the blood vessels. No ill-effects were felt although the apparent cyanosis caused a great deal of comment.

In view of this bizarre side-effect, it was decided to dispense with the use of Evans blue as an indicator of histamine release. Subsequently the injections of the muscle relaxants and the sterile water control were made intradermally as described above but Evans blue was not used.

Ten patients were used for each muscle relaxant and for the control. In each case the anæsthetic was thiopentone, nitrous oxide, oxygen, and trichlorethylene and the opera-

tion performed was cystoscopy and any necessary intravesical procedure. Readings were taken after five minutes. As the flare in each case was found to be proportional to the wheal, only the wheal was measured.

TABLE I

Results

Relaxant	Size of the wheal in square mm.		
	Maximum	Minimum	Average
d-Tubocurarine chloride	270	160	192
Dimethyltubocurarine iodide	220	150	190
Gallamine triethiodide	190	125	153
Decamethonium iodide	115	70	91
Control	55	28	36

From the above table it can be seen that d-tubocurarine chloride releases the largest amount of histamine. Next come dimethyltubocurarine iodide, gallamine triethiodide, and decamethonium iodide in that order. In each case the wheal area is much larger than that of the control area.

d-Tubocurarine chloride and dimethyltubocurarine iodide are almost equal in their ability to release histamine.

Various other substances produce a wheal and flare when injected, amongst these are morphine and atropine (Wright, 1945). In two cases, in whom a definite wheal and flare followed the injection of morphine and atropine given as premedication, a sample of d-tubocurarine chloride was injected as described above. These patients might have been expected to show a greater response than the others. In fact, however, the resultant wheal was no larger.

DISCUSSION

The investigation which has been described was conducted from a pharmacological point of view. No investi-

gation has been made into its clinical significance. Nevertheless one has noted that it is easier to perform intubation and also bronchoscopy in patients given gallamine triethiodide, than in those given d-tubocurarine chloride. One would be tempted to attribute this to the fact that gallamine triethiodide releases less histamine than d-tubocurarine chloride with a lesser tendency, consequently, to produce bronchospasm. This, of course, is a subjective clinical impression. There is, however, a technique now being used in anæsthesia which admits of a more objective analysis. This is " controlled hypotension " using hexamethonium or pentamethonium salts. These drugs act by blocking the autonomic ganglia and so one has a state of affairs analogous to the experiments carried out by MacIntosh and Paton on cats. It would be interesting, therefore, to know if anyone has found, using this technique, that the injection of a muscle relaxant causes a further fall in blood-pressure, due to histamine release, as occurred in the cats.

SUMMARY

(1) A method of estimating and comparing histamine release by muscle relaxants in man is described.

(2) The results of a series of experiments using this technique suggest that d-tubocurarine chloride releases the largest amount of histamine and next come dimethyltubocurarine iodide, gallamine triethiodide, and decamethonium iodide in that order.

(3) The controlled hypotension technique affords an opportunity of examining these facts clinically.

I wish to thank the members of the anæsthetic staff of the Victoria Infirmary for their help and encouragement in the preparation of this paper, and to Messrs. Allen and Hanburys Ltd. for a supply of dimethyltubocurarine iodide.

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SUCCINYLCHOLINE IODIDE*
A NEW MUSCULAR RELAXANT

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SUCCINYLCHOLINE IODIDE is a synthetic quaternary ammonium salt, which has a neuromuscular blocking action of short duration.

The substance was first discovered in 1906 by Hunt and Taveau, but they did not discover its paralysing effect. This property of succinylcholine was demonstrated for the first time by Bovet in 1949 (Bovet, Bovet-Nitti, Guarino, Longo and Marotta 1949). He also studied its hydrolysis and showed that it was broken down by cholinesterases and that its action was considerably prolonged by neostigmine and physostigmine. The last-mentioned finding was confirmed by Castillo and de Beer in 1950. Bovet also reported acetylcholine-like effects on the blood-pressure.

Succinylcholine iodide was produced by Löw and Tammelin in 1950 and used in pharmacological and clinical tests (Thesleff, 1951).

Succinylcholine is broken down rapidly in the body by esterases (Bovet-Nitti, 1949; Ginzel, Klupp and Werner, 1951), probably into succinic acid and choline, both of which are natural metabolites. This presumably explains the short duration of its action and extremely low toxicity.

Succinylcholine, like d-tubocurarine, acts on the myoneural junction. There are, however, strong reasons to

* The preparation is manufactured by Vitrum, Stockholm.

suppose that its mode of action is not similar to that of d-tubocurarine. At present, it appears most probable that it acts in the same way as decamethonium or as large doses of acetylcholine, i.e., by depolarizing the muscle end-plate and the surrounding muscle fibres. This property of the substance has also recently been confirmed by Ginzel, Klupp and Werner (1951).

Succinylcholine is a powerful neuromuscular blocking agent, its potency being slightly less than that of d-tubocurarine. Thus, the HD 50 for succinylcholine is approximately 0.20 milligrams per kilogram body weight, whereas it is 0.15 milligrams per kilogram for d-tubocurarine.

As stated earlier, the effect of succinylcholine is very short—from one to ten minutes, depending on the dose. When injected intravenously, it takes action so rapidly that complete muscular relaxation is obtained within 30 to 60 seconds. Very transient muscular fibrillations occur immediately before the onset of paralysis. This is a completely harmless phenomenon, which also accompanies the administration of other drugs with a similar chemical structure. The muscles are paralysed in the following order: those of the eyes and throat are the first to be affected, followed by the peripheral muscles, the muscles of the thorax and, finally, the diaphragm. The order is thus the same as with d-tubocurarine.

The dose which paralyses the peripheral muscles but does not depress respiration is approximately half that required to bring about respiratory arrest.

In no cases have any noteworthy effects on the blood-pressure, either with large or small doses of succinylcholine, been observed.

Animal experiments and intracutaneous injections on man have shown that succinylcholine does not liberate his-

tamine. Therefore, even in large doses, it does not result in bronchial spasm. It has no paralysing effect on transmission in the autonomic nervous system, nor does it influence intestinal motility. The electroencephalograms of unanæsthetized human subjects have shown that the central nervous system remains unaffected.

Succinylcholine may be used together with various anæsthetics without any noteworthy change in its effect. Thus, there is no potentiation with ether. It may be mixed with different barbituric acids, but the alkaline pH of the mixture will then cause it to be broken down more rapidly.

Succinylcholine has a certain antagonism to other curare preparations on account of their different sites of action in neuromuscular transmission. Thus succinylcholine in suitable doses has an antagonistic action to muscular relaxation produced by d-tubocurarine and tri(diethyl-aminoethoxy)benzene triethiodide (Flaxedil). The converse does not appear to occur.

Because succinylcholine is broken down by esterases, its action may be prolonged with esterase-inhibitors such as neostigmine. The effect is not, however, pronounced in man. In order to obtain greater prolongation toxic doses must be given. The method cannot, therefore, be used clinically. There is no antidote to succinylcholine, but its rapid breaking down in the body is the best protection against overdosage.

The action can be prolonged by giving succinylcholine by intravenous drip. It is then possible to obtain complete muscular paralysis, both in animals and in man, for several hours without toxic reactions. The effect and depth of "curarization" have proved very easy to control by this method.

Since January 1951, succinylcholine has been used at the Department of Anæsthetics of Karolinska Sjukhuset in

more than 1,000 instances; in 132 surgical operations (v. Dardel and Thesleff 1951), 512 electro-shock treatments at the Psychiatric Clinic (Holmberg and Thesleff 1951), and the remainder in various operations on out-patients from the surgical and other clinics. Succinylcholine was given to patients belonging to all risk-groups and age-groups with the exception of infants. In the Surgical Clinic it was mainly used in abdominal surgery, but operations on the thorax, urinary tract, extremities and head were also included.

Succinylcholine was used as an adjunct to all the common anæsthetics. Thus it has been used together with barbiturates, for example thiopentone, with nitrous oxide, ether and cyclopropane. Anæsthesia has, as a rule, been induced with the intravenous administration of a short-acting barbiturate and continued with the anæsthesia combination considered suitable. Succinylcholine was given when muscular relaxation was desired, for instance, for intubation or abdominal operations, if necessary until respiratory arrest occurred.

Succinylcholine is supplied in glass ampoules containing 100 mg. of dry substance. Before use it is dissolved in 10 ml. of sterile saline. Each ml. thus contains 10 mg. of succinylcholine. The solution is non-irritating to the tissues and does not induce hæmolysis. Succinylcholine is administered intravenously.

For intubation we use 40–80 mg., according to the patient's weight, injected rapidly intravenously. After approximately 45 seconds transient muscular fibrillations occur. Immediately after their cessation, the patient is completely relaxed and intubation is easily performed. If laryngeal spasm occurs during anæsthesia, it is easily arrested by giving succinylcholine. With adequate doses of this substance, the vocal cords are maximally relaxed and

immobile and do not react to touch. Little damage is therefore caused by intubation. Thus, laryngeal spasm does not prevent a free airway even in operations without intubation.

If prolonged muscular relaxation is required, repeated doses of the preparation are given, its short action making regulation of relaxation simple. In such cases initially we gave approximately 10 mg. every third minute. Later, we found it more convenient to give succinylcholine by intravenous drip. We used a concentration of 1–2 mg. per ml. of physiological saline given at a rate of 40–60 drops per minute (2–8 mg.). This quantity results in relaxation of the peripheral muscles without respiratory depression. We found regulation of the dose extremely easy with this procedure and no difficulties were encountered in maintaining muscular relaxation for a longer period of time. Because the preparation is broken down rapidly, there is little risk of overdosage. Obviously, it is necessary to keep a careful check on the patient's ventilation during the whole time he is under anæsthesia.

Using the intravenous drip method, 200–400 mg. of succinylcholine are required per hour. If this dilution necessitates the administration of too large a quantity of fluid, a stronger concentration may be used.

We used succinylcholine in a number of other instances in which muscular relaxation was required, such as reduction of fractures and dislocations, mobilization of joints and cystoscopy. The dosage was adapted to the nature and duration of the procedure.

We had no complications during anæsthesia or during the post-operative course that could be ascribed to the preparation. Thus we have found no abnormal changes in blood-pressure nor has the heart rate been affected.

Neither bronchial spasm, increased salivation, nor other similar symptoms occurred.

We used succinylcholine in a patient with myasthenia gravis without any complication.

When using succinylcholine as a muscular relaxant in electro-shock therapy our method was as follows. The patient received a mixture of 150 mg. of thiopentone and succinylcholine corresponding to 0.3 mg. per kg. body weight. This mixture was injected intravenously during a period of 60 seconds, the patient simultaneously inhaling 100 per cent oxygen. Twenty seconds after termination of the injection, electro-shock was given. Using this technique, the majority of patients had only slight muscular twitchings; they were so relaxed that the extremities were not lifted from the surface on which they were lying. As a rule, respiration returned to normal after 1 to 2 minutes. Thus, it has been possible with this procedure to obtain satisfactory muscular relaxation without lengthy respiratory arrest or anoxia. The entire treatment requires only seven minutes and, since succinylcholine is broken down so rapidly, supervision of the patient for any length of time after treatment is unnecessary.

SUMMARY

Succinylcholine has been used in more than 1,000 instances to obtain muscular relaxation. In every case the results were good. No toxic effects that could be ascribed to the preparation were observed during anæsthesia or postoperatively. The preparation was well tolerated even by elderly persons and patients who were considered poor risks. The substance is rapidly broken down into normally occurring metabolites. There are no contra-indications for its use. The advantages of succinylcholine iodide are

particularly apparent in those cases in which muscular relaxation of short duration is required. In our opinion, the low toxicity of the preparation and the absence of side-effects make it superior to other muscular relaxants available, even in lengthy surgical operations.

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A REPORT ON THE USE OF SUCCINYLCHOLINE CHLORIDE IN A THORACIC UNIT

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FOLLOWING the demonstration by Bovet et al (1949) and, independently in this country, by Buttle and Zaimis (1949), of the powerful muscular blocking activity of succinylcholine, there has been much discussion in the literature regarding the merits and demerits of this drug in anæsthetic practice.

The chemistry and pharmacology of this compound have been adequately reviewed by Glick (1941), Castillo and de Beer (1950), Bourne and Somers (1951) and Mayrhofer (1952).

It is our purpose to present our experiences using succinylcholine chloride in a series of bronchoscopic and œsophagoscopic examinations.

In performing these examinations, succinylcholine has been administered without complications to a consecutive series of 1,000 patients ranging in age from 21 months to 83 years.

TECHNIQUE

The solution of succinylcholine we have used is that supplied by Allen & Hanbury's, a clear, colourless, 5 per cent solution (" Scoline ") provided in 2 ml. ampoules.

Premedication. In adults, an injection of 1/6 gr. (10 mg.) of morphine and 1/100 gr. (0.65 mg.) of atropine is given 1 hour before the examination. In children, atropine alone is used.

Induction. A serum needle attached to a Blease-Halton 2-way tap is inserted into a suitable vein and then connected to a saline drip.

A sleeping dose of sodium thiopentone is injected and followed by a dose of succinylcholine. The doses employed depend on the age, weight and general condition of the patient; for sodium thiopentone 250–400 mg., for succinylcholine, 20–50 mg.—a dosage much less than that recommended by the manufacturers (50–100 mg.). A usual dose for an adult is 350 mg. of thiopentone followed by 35 mg. of succinylcholine.

A variant of this technique is to sandwich the injection of succinylcholine between two injections of thiopentone. The advantage of this method is that the optimal effects of each drug more nearly coincide and it is thereby possible to use minimal doses of each drug.

The lungs are then inflated with oxygen and the bronchoscope passed. During these examinations a flow of oxygen of 2 litres/min. is administered, in bronchoscopy through the side tube of the bronchoscope and in œsophagoscopy through a gum elastic catheter inserted into the trachea for this purpose.

A careful watch is kept on the patient's colour and pulse and further increments of succinylcholine and/or thiopentone given as required.

To ensure adequate oxygenation of the patient during examinations lasting more than the customary 3–5 min., there are two manœuvres which will help to improve the oxygen content of the residual air in the less well ventilated parts of the lungs.

These manœuvres are:

1. Intermittent blockage of the bronchoscope opening with a finger with the oxygen by-pass open, so inflating the lung.

2. Manual massage of the upper abdomen with resultant elevation of the diaphragm and compression of the lower lobes of the lungs particularly, thereby dispersing a percentage of the residual air present.

OBSERVATIONS

Within 5–30 sec. following the injection of succinylcholine, muscle fibrillations are observed in all cases. The muscle twitches vary in duration, distribution and degree. Complete muscular relaxation follows in 5–10 sec. The intensity of these effects appears to be unrelated to the dose of succinylcholine given or to the muscularity of the individual patient.

The duration of respiratory paralysis is approximately 2–4 min., occasionally 6 min. When spontaneous respiration reappears it is completely adequate within one minute of complete apnœa.

No unexpected or significant changes in the patient's pulse rate, rhythm or force have been noted, and no evidence of increased salivation observed.

ADVANTAGES

Duration of Relaxation. "The use of succinylcholine in bronchoscopy proved difficult, since the patient passed too rapidly between the extremes of paralysis and strength. Here gallamine with thiopentone was preferred. But, provided the lungs were well inflated beforehand with oxygen, the use of succinylcholine in bronchoscopy was satisfactory when the examination was brief or the surgeon permitted interruptions for reinflation."

This statement, in a recent paper by Bourne, Collier and Somers (1952) based on 4 bronchoscopies, 20 œsophagoscopies, is in direct contrast with our experience. The duration of anæsthesia and relaxation has been adequate

in all cases, ensuring a thorough examination and a satisfied surgeon.

Some cases, however, require successive doses of succinylcholine of the order of 25 mg. to prolong the period of relaxation, permitting a more than brief examination. This is well illustrated in the following case report.

> An obese female patient, aged twenty-five years, required an œsophagoscopy for the removal of a safety pin lodged at the cardio-œsophageal junction. In this case the surgical manipulations occupied one hour. For this prolonged period, relaxation and anæsthesia were maintained with an initial dose of 350 mg. thiopentone plus 35 mg. succinylcholine followed by successive increments to a total dosage of 500 mg. of succinylcholine and 1½ g. of thiopentone. The 2-litre flow of oxygen maintained satisfactory oxygenation throughout, no cyanosis being observed. At the completion of the operation, respirations were normal and the patient conscious.

Though this case is a little extreme, there is no difficulty or danger in obtaining satisfactory relaxation for periods of 15–20 mins. without modification of the technique described.

Where incremental doses of succinylcholine have been given further muscular twitchings were not observed, nor was prolonged apnœa a feature. There were no additive effects seen and this ensures the anæsthetist maintaining full control of the duration of relaxation when successive doses of succinylcholine are used.

Degree of Relaxation. The excellent relaxation of the vocal cords obtained so quickly with succinylcholine facilitates easy passage of the bronchoscope with minimal trauma to the larynx. Moreover the apnœa accompanying the relaxation and terminating with it favour the necessary surgical manipulations during the examinations.

Though techniques using other relaxant drugs such as d-tubocurarine chloride or gallamine triethiodide with

thiopentone have been used extensively by us in the past, for the above reasons surgical and anæsthetic opinion in the Thoracic Unit is now unanimously in favour of succinylcholine.

Rapidity of Action. The rapid action of succinylcholine favours the early introduction of the bronchoscope without that reaction from the patient which is seen not uncommonly with the longer-acting relaxants. The rapidity of obtaining relaxation and of recovery is an important factor in a busy Thoracic Surgical Unit.

Laryngeal Spasm. This has been a not uncommon feature after bronchoscopy when other relaxant drug techniques have been used. In our series using succinylcholine, the incidence of this complication has been markedly reduced. In the few cases in which it did occur, the spasm was mild in degree and of short duration.

Two possible explanations may account for this observation:

(a) The completeness of relaxation facilitates the atraumatic passing of the bronchoscope.

(b) The degree of histamine liberation in comparison with that of d-tubocurarine chloride is small (Bourne, Collier and Somers, 1952). However, though histamine may play a part in the causation of bronchial spasm, what relation it might have to the occurrence of laryngospasm is problematical.

DISADVANTAGES

Prolonged Respiratory Paralysis. There have been several reports in the recent literature of cases of prolonged respiratory paralysis following succinylcholine (Gould, 1952; Harper, 1952; Langton Hewer, 1952; Hurley and Monro, 1952; Love, 1952; Sherman, 1952). In only one

case in this series of 1,000 did apnœa persist for more than six minutes following the single initial dose of succinylcholine.

Case Report. A middle-aged male patient suffering from pulmonary tuberculosis received a dose of 500 mg. of thiopentone and 50 mg. of succinylcholine for bronchoscopy. Apnœa persisted at the conclusion of the bronchoscopy and inflation of the lungs with oxygen was carried out during this period. Twenty minutes after the injection of succinylcholine spontaneous respirations began to return and were normal within a further minute.

The explanation of the prolonged apnœa in this case remains obscure.

Several theories have been suggested to explain such occurrences.

1. Excessive dosage (Foldes, 1952).
2. Hyperventilation with oxygen (Richards and Youngman, 1952).
3. Deficiency of plasma, "pseudo" cholinesterase (Bovet et al, 1949; Evans et al, 1952).

In the case described, the first theory would not seem to apply, as the dose used was much less than that advocated by many authors. The second possibility could account for the occurrence but is unlikely, as many other patients have had the same degree of ventilation. The third theory, recently supported by the work of Evans et al. (1952), is the most probable in the light of our present knowledge.

CONCLUSION

The anæsthetic technique described, using succinylcholine for bronchoscopic and œsophagoscopic examinations, has now completely supplanted in the Liverpool Thoracic Surgical Unit other relaxant techniques, viz.:—thiopentone with d-tubocurarine chloride or gallamine triethiodide.

We believe for the reasons given that the advantages of this drug far outweigh any possible disadvantages.

We should like to thank Messrs. Allen & Hanbury's for their generous supplies of succinylcholine in the early stages of this series.

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ANÆSTHESIA FOR CEREBRAL ANGIOGRAPHY*

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HISTORY

CEREBRAL angiography entails the radiographic demonstration of the cerebral arteries and veins following the intra-arterial injection of a contrast medium.

In 1927 Egas Moniz (1934), Professor of Neurology at Lisbon, introduced a 25 per cent solution of sodium iodide into the carotid artery. This procedure unfortunately resulted in a high incidence of fits despite pre-operative phenobarbitone. By 1931 he had performed 300 arteriograms when he abandoned sodium iodide and began using thorotrast, a 25 per cent suspension of thorium dioxide. Thorotrast was non-irritating and gave good contrast on subsequent films. It was, however, permanently radioactive and Northfield and Russell (1937) demonstrated histological retention of thorotrast in the walls of cerebral vessels. It was also stored in the reticulo-endothelial system, and in some cases could be demonstrated in the liver and spleen months after introduction into the circulation. MacMahon et al. (1947) reported a case of endothelial-celled sarcoma of the liver following an injection of 75 ml. of thorotrast twelve years previously. Furthermore, by using a Geiger Müller counter, radioactivity was shown to be present in the liver at post-mortem. For these reasons thorotrast is now very rarely used in angiography.

Gross (1940) in America first reported using Diodone

* A paper read to the Royal Society of Medicine (Anæsthetic Section) on May 2nd, 1952.

FIG. 1

X-ray film showing a normal lateral angiogram. The carotid siphon and the anterior and middle cerebral vessels are filled with diodone.

FIG. 2

X-ray film showing a normal antero-posterior angiogram. The branches of the anterior cerebral artery are in the mid-line while the middle cerebral branches are seen fanning out over the lateral aspect of the hemisphere.

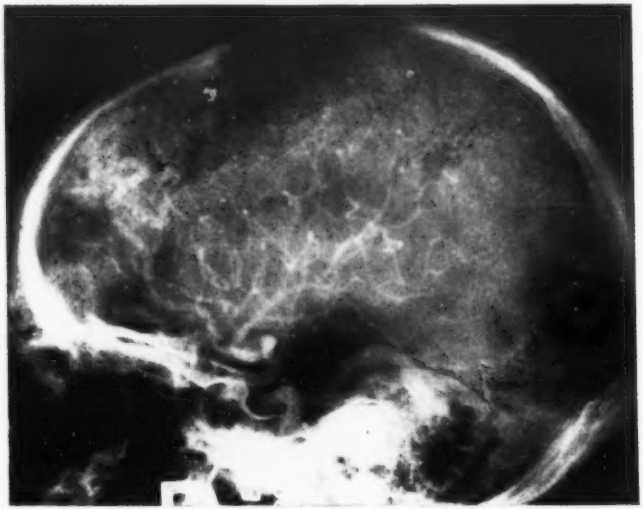

FIG. 3

X-ray film showing a lateral angiogram with a frontal lobe angioma. A large branch of the anterior cerebral artery is seen running to supply it.

FIG. 4

X-ray film showing an antero-posterior angiogram with a " berry " aneurysm of the Circle of Willis.

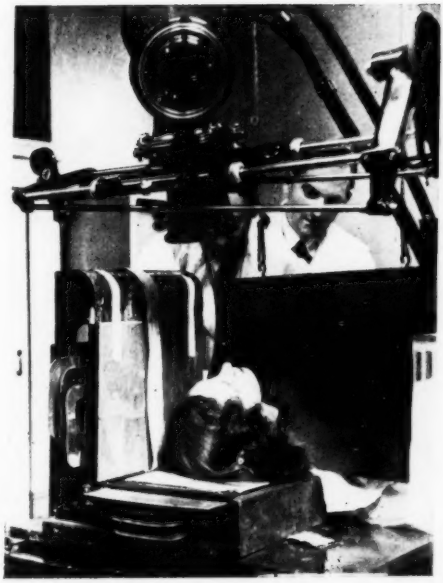

FIG. 5

The patient's head rests on the cassette holder, the X-ray tube being in position for the antero-posterior view.

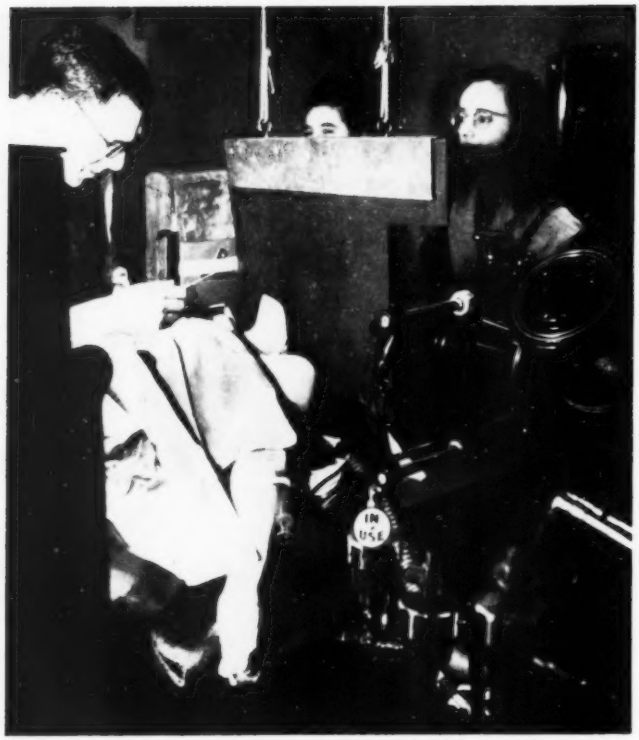

FIG. 6

The needle is about to be inserted into the neck after being filled with saline. The X-ray tube is in position for the lateral view.

compounds, which consist of a form of iodine in which the characteristic pharmacological activity of this substance is suppressed and which are stable in aqueous solution and speedily excreted from the body by the kidneys. Because the resultant films were of lower contrast to those when thorotrast was employed a concentrated solution of Diodone 70 per cent was used. Unfortunately complications followed, and fits, thrombosis and prolonged loss of consciousness were reported (Dyke, 1940). These are, however, not often seen when a weaker solution is used.

Broman and Olssen (1948) in experiments in dogs with Diodone, found altered permeability of the blood-vessels of the brain which may give rise to œdema, depending on the concentration used and the time the solution is in contact with the brain. Thus, slowing of the cerebral circulation may increase the number of complications. He recommended using a concentration less than 50 per cent and in this series a 40 per cent solution has been used.

In 1927 Egas Moniz (Wickbom, 1948) tried on four occasions to inject the carotid artery by the percutaneous route but failed and resorted to the open method of exposing the carotid artery and injecting under direct vision. In 1929 Lomas and Myerson began treating general paralysis of the insane by injecting arsphenamine into the carotid artery and in 1936 they applied this technique to cerebral angiography (Loman and Myerson, 1936). The method did not become established until 1944 when Engeset in Norway developed the percutaneous route and Lindgren (1947) in Britain firmly established it as routine procedure.

DETAILS OF CASES UNDER REVIEW

In the last 18 months, 169 angiograms have been performed on 102 patients. The presenting symptoms are summarized in Table I.

TABLE I

Presenting Symptoms	No. of Cases	No. of Pathological Angiograms
Paralysis	33	17
Epilepsy	28	6
Subarachnoid haemorrhage	19	11
Disorders of vision	7	0
Aphasia	7	4
Headache	8	0
Total	102	38

The 38 pathological angiograms are analysed in Table II.

TABLE II

	No. of Cases
Thrombosis artery	8
Aneurysm	7
Angioma	6
Glioma	7
Meningioma	1
Secondary carcinoma	3
Undifferentiated tumour	4
Post traumatic cyst	1
Cerebral abscess	1
	Total 38

Figures 1 and 2 show normal lateral and antero-posterior angiograms. Figure 3 is of a frontal lobe angioma, and figure 4 shows a berry aneurysm of the Circle of Willis.

ANGIOGRAPHIC TECHNIQUE

We have performed angiograms on 102 patients and but for two children the percutaneous method has been used. A description of the technique used is necessary for an appreciation of the anæsthetic difficulties.

The patients are placed on the X-ray table with their backs supported on pillows and their heads resting on the cassette holder (figs. 5 and 6). This special holder allows the rapid serial exposure of three films each for the antero-posterior and lateral views. The leaded rubber screen

cut to fit round the patient's neck is to protect the radiologist's hands from direct radiation. Care must be taken to avoid pressure sores from direct contact with the sharp vertical edge of the cassette holder which often presses on the patient's shoulder.

Two radiologists are present, one to puncture the artery and the other to inject the contrast solution. The common carotid artery is palpated one inch above and one inch lateral to the sternoclavicular junction where the artery is comparatively superficial in the carotid triangle covered by skin, platysma and deep cervical fascia. In some patients where there is low division of the carotid artery the internal carotid may be entered and the region of the carotid sinus is not infrequently needled. If local anæsthesia is employed the patient experiences considerable discomfort and choking sensation from pressure with the fingers fixing the artery prior to puncture, unless this is done gently.

A No. 18 gauge lumbar puncture needle 4 inches long is used for arterial puncture and is connected to a length of pressure tubing with intervening glass tubing to act as an inspection window. To the far end of the tubing is attached another adaptor into which a nozzle of a syringe can be fitted. A 20 ml. syringe containing physiological saline is attached and the tube and needle are filled with solution: this is important in order to avoid air embolism. Once the skin is pierced, the saline syringe is disconnected and the artery sought. This may take anything from seconds to many minutes. When the artery is entered, blood is seen flowing back through the inspection window. The syringe is then re-attached and saline slowly injected until all is ready for exposing the films. No obstruction to injection should be present, for if clot formation should occur, the rapid injection of contrast medium would dislodge the clot and a cerebral embolus would result. If the

saline flows freely the needle is still in the artery. A 20 ml. syringe containing 40 per cent Diodone is attached and injection as fast as possible begun. The first film is exposed after 8 ml. is injected, the second two seconds later, and the third two seconds after that. If done under local anæsthesia, the patient feels a burning sensation in the distribution of the vessel injected and unless he co-operates by remaining perfectly still, the pictures will be blurred. The syringe containing the saline is re-attached and the needle kept patent by slow injection of saline whilst the X-ray tube is rotated for the antero-posterior view. If the needle is still in the artery the same routine of injection is repeated. Approximately 32 ml. of the solution is used for each complete angiogram. In some patients a bilateral angiogram is necessary and a minimum time of forty-five minutes is required. However, this is often exceeded in technically awkward cases. After withdrawal of the needle, pressure is maintained on the neck at the site of entry into the artery to minimize hæmatoma formation.

ANAESTHETIC TECHNIQUE

Local anæsthesia with procaine after premedication with Nembutal, Omnopon and Scopolamine is recommended in the literature (Friel, 1950). There is, however, scanty reference to the use of general anæsthesia for cerebral angiograms. Curtis (1950) of Oxford states that " if the patient is under light general anæsthesia there is often a sudden move of the head at the moment which corresponds to the exposure of the films and that it is better to work with a conscious patient ". However, he says later that with young children and with unco-operative or mentally deranged patients general anæsthesia is necessary, but no details are given.

Rait-Smith (1949) stated that " carotid arteriography

should not be attempted under nitrous oxide and oxygen anæsthesia alone, for there must be no risk of the patient coughing".

From the above description of the technique of cerebral angiography it is apparent that the following requirements must be satisfied if a general anæsthetic is to be used:

1. The patient must be protected from pressure on the carotid sinus, which can produce a fall of blood-pressure as may be seen in figure 7.

2. The patient must remain still during the injection of the Diodone.

3. Anoxia and congestion of the neck veins must be avoided by remote control of the airway.

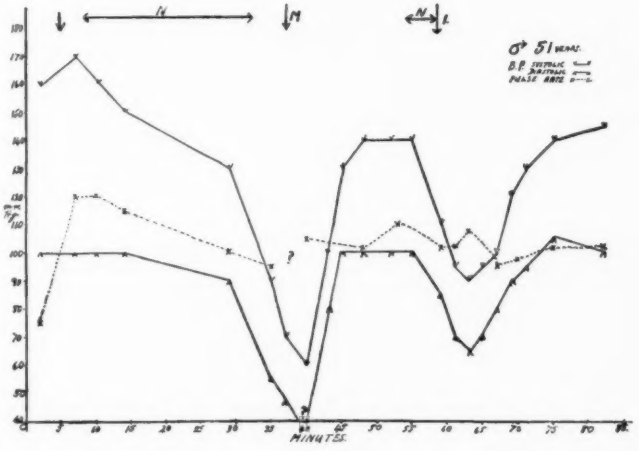

FIG. 7

Right carotid angiogram for the investigation of epilepsy in a man aged 51. Continuous needling ($\overset{N}{\longleftrightarrow}$) of the carotid artery for 24 minutes produced extreme hypotension necessitating the intravenous injection of methedrine 30 mg. (↓ M) in divided doses. A further drop in systolic and diastolic pressure occurred on injection of 32 ml. Diodone 40% (↓ I.).

4. Non-explosive agents must be employed, for even though modern X-ray apparatus is spark proof, the proximity to potentially dangerous apparatus in my opinion necessitates the exclusion of all explosive anæsthetics.

Of the 102 cases under consideration 39 patients have been given 42 general anæsthetics for 62 angiograms. Figure 8 shows the age distribution and demonstrates that the majority of general anæsthetics have been given to the younger age groups. The main indications for a general anæsthetic

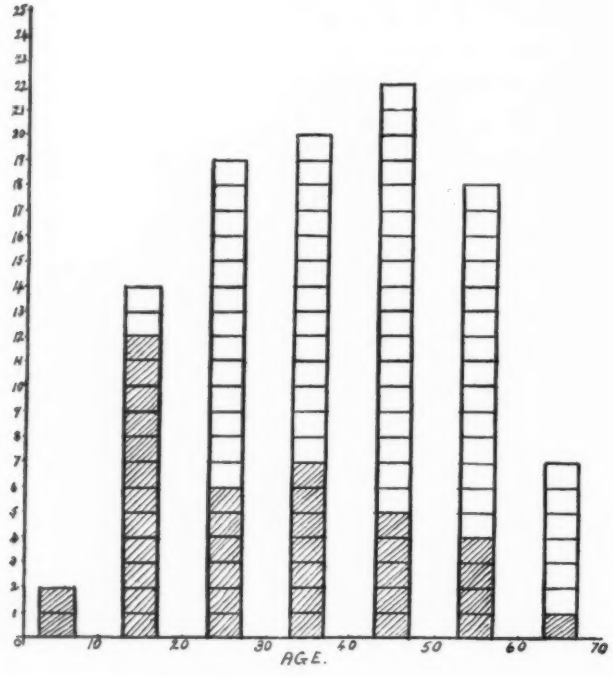

FIG. 8

Age distribution, the shaded cubes indicate the numbers in the different age groups that were given general anæsthetics for angiograms.

have been an unco-operative patient or a previous failure with local. Three "failures with local" refused to return for further investigations.

When using a general anæsthetic I premedicate adults with morphia gr. 1/6 (10 mg.), atropine gr. 1/100 (0.65 mg.), one and one quarter hours pre-operatively so that the maximum respiratory depression is passing off by the time the patient reaches the X-ray department. The morphia is omitted if the patient is drowsy or in poor general condition. Children may be given rectal thiopentone 1 g./50 lb. body weight and atropine gr. 1/100 (0.65 mg.) half an hour pre-operatively.

Whether local or general is used the patient must have an empty stomach prior to the injection of Diodone, for in a small percentage of cases vomiting is seen immediately following injection.

An endotracheal tube of adequate bore is essential for complete control of the airway, thus avoiding anoxia and venous congestion. Care must be taken that the tube does not become kinked at the level of the soft palate. The endotracheal tube is brought out of the side of the mouth and carefully placed so that it is not in the way of the radiologist or liable to appear on the exposed film.

For cardio-angiography at Guy's Hospital, Carnegie (1951) recommended endotracheal closed circuit cyclopropane and ether. This was to afford the patient protection from bronchospasm and transient anoxia associated with the introduction of 70 per cent Diodone on the venous side of the heart. In my experience of cerebral angiography, I have never observed bronchospasm associated with the injection of Diodone.

Anæsthesia is induced with minimal thiopentone, usually 500 mg., but often less will be required as these patients are not infrequently receiving long-acting barbiturates for

the control of fits. Gallamine triethiodide 60 to 80 mg. is injected through the same needle and the thiopentone syringe is replaced and strapped to the arm. A mask is applied and the patient is given pure oxygen by intermittent inflation of the lungs for 30 seconds by gentle pressure on the reservoir bag. When relaxation of the jaw occurs, a Macintosh laryngoscope is introduced, the larynx sprayed with 2 per cent amethocaine from a Rowbotham spray, the endotracheal tube passed and connected to a Boyle's machine. Anæsthesia is then maintained with 70 per cent nitrous oxide and 30 per cent oxygen with minimal trichlorethylene.

It is essential to intubate smoothly with no coughing and straining, otherwise the neck veins become distended and are liable to be damaged on seeking the carotid artery. The resultant hæmatoma may make it impossible to palpate the artery. If it is necessary to adjust the position of the patient relative to the X-ray film, a little more thiopentone may need to be injected. In the majority of cases spontaneous respiration is rapidly re-established but if the respiration is in any way depressed it is essential to assist it by compression of the reservoir bag. Recently I have used succinylcholine chloride, in intermittent injections of 50 mg., with nitrous oxide and oxygen during the period of apnœa. With this technique, however, I have found it difficult to maintain an even plane of anæsthesia and venous engorgement of the neck tended to occur. I have found succinylcholine of great value for peripheral angiography, e.g. for femoral angiograms, where the whole procedure is completed in three to five minutes. However, cerebral angiography takes considerably longer and large quantities may be required. In view of recent reports (Blair-Gould, 1952; Love, 1952; Harper, 1952) concerning prolonged apnœa following single doses of succinylcholine, I ques-

tion whether it is justifiable to use succinylcholine for maintenance. It may, however, have a place as a single dose for intubation. Using gallamine triethiodide I have found that a lighter plane of trichlorethylene anæsthesia suffices to give a smooth anæsthesia to ensure that the patient remains immobile during needling of the artery and injection of Diodone. I prefer gallamine triethiodide to d-tubocurarine chloride for the apnœa produced is usually transient. It is possible that the vagolytic action of gallamine triethiodide may be a factor in protecting the patient from stimulation of the carotid sinus. Tachycardia is seen in approximately 30 per cent of the cases; it does not, however, interfere with palpation of the artery as the blood-pressure is not reduced. Once the vessel is entered any movement, apart from blurring the films, may cause the point of the needle to come out of the artery and Diodone may be injected into the carotid sheath. The radiologist may not then be able to re-enter the artery. It is thus essential that the patient does not strain or move once the artery is entered. The trichlorethylene is cut off as the last injections are made, but the endotracheal tube is not removed until the films have been developed in case repeat injections are required. Anæsthesia is usually quite light and on extubation laryngeal spasm may occur (Gillespie, 1948). This is treated in the usual way by oxygen under pressure. Atropine gr. 1/50 (1.3 mg.) and neostigmine 5 mg. are rarely needed but are given if any residual respiratory depression is present.

COMPLICATIONS

These can be separated into those associated with puncture of the artery and those due to Diodone.

Hæmatomata. A perivascular hæmatoma may develop from accidental damage to a vein or from puncture of the

artery. Cases have been reported where deviation of the trachea due to hæmatoma formation has resulted in respiratory obstruction (Dunsmore et al, 1951), and extravascular injection of Diodone may aggravate this. Aspiration of the hæmatoma may be required, but usually it disappears rapidly within twenty-four to thirty-six hours, not so much by absorption as by tracking down the carotid sheath into the mediastinum. Byrd and Jensen (1951) have described transient palsy of the vocal cords associated with deviation of the trachea with resultant respiratory obstruction. Foltz (1952) in experiments with monkeys showed that if Diodone is injected below the bifurcation of the carotid artery, swelling and œdema of the neck muscles and soft tissues can occur. This effect is due to the Diodone in the external carotid artery and is never seen following injection of the internal carotid alone. Following percutaneous injection in man, this swelling may be mistaken for local extravasation of blood or Diodone.

Cerebral Hæmorrhage. The ideal contrast medium for cerebral angiography has not yet been found. Foltz (1952) demonstrated a direct vascular effect on cerebral vessels after intra-arterial injection of Diodone. This consisted of a severe vascular spasm followed by prolonged vascular dilatation. Hæmorrhage into a tumour has been described following cerebral angiography (Bull, 1949). In our series a male patient aged 68 with three months' history of amnesia and right hemiplegia of slow onset collapsed three hours after bilateral angiography under local anæsthesia. He died twelve hours later and, at post mortem, hæmorrhage into a left parietal tumour was found.

Hypotension and Cerebral Thrombosis. A generalized vascular dilation follows the entry of the Diodone into the general circulation. Figure 9 shows transient falls in both systolic and diastolic pressure related to the injection of

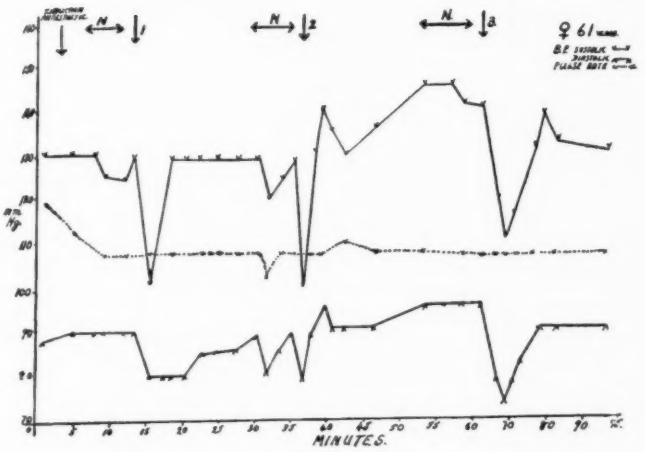

FIG. 9

Bilateral carotid angiograms for the investigation of nominal aphasia of recent onset in a female aged 61. Needling ($\overset{N}{\longleftrightarrow}$) produced minor falls in blood-pressure whilst the injection of 32 ml. Diodone 40% at ($\downarrow 1, \downarrow 2, \downarrow 3$.) resulted in more marked falls in both systolic and diastolic pressure.

Diodone: needling of the artery resulted in minor changes. At the end the blood pressure was at the preoperative level. This is in contrast to figure 10 which is drawn from pressures recorded during a bilateral angiogram in a hemiplegic man aged 50. Here progressive falls are seen with little subsequent recovery.

In elderly arteriosclerotic patients Ecker and Deren (1941) reported apoplexy apparently precipitated by hypotension. In our series one patient, a female aged 57, with a history of left hemiparesis nine years ago and a systolic bruit on the right side of the skull, collapsed whilst under going a right carotid angiogram under local anæsthesia. She developed a right hemiparesis and after initial improvement died within twenty four hours. At post

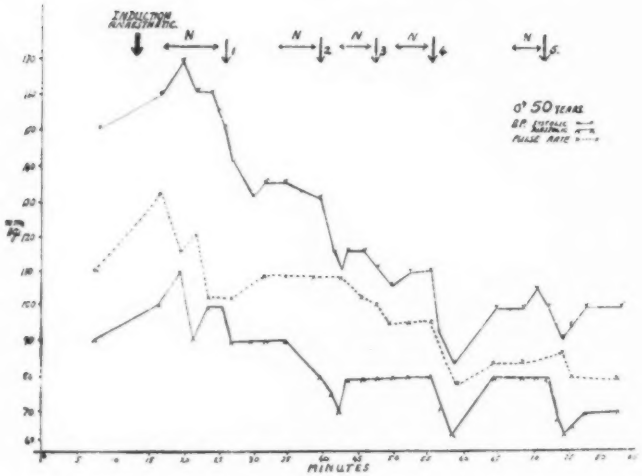

FIG. 10

Bilateral carotid angiogram for the investigation of hemiparesis of slow onset, in a man aged 50. The procedure resulted in an overall fall in blood-pressure due to failure in recovery following the injection of 16 ml. 40% Diodone at ↓1, ↓2, ↓3, ↓ 4, ↓ 5.

mortem, generalized cerebral atheroma was present. Just beyond the origin of the left middle cerebral artery there was a gross patch of atheroma practically occluding the artery, distal to which was an antemortem thrombosis which was the cause of death.

Vascular spasm may be the cause of hemiparesis and stellate ganglion block has been used by Dunsmore et al (1951) in America in an attempt to relieve vasospasm. It was not followed by immediate improvement though the patient recovered, apart from some residual slurring of speech. Chusid et al (1949) have described the use of tetra-ethyl ammonium chloride to relieve vessel spasm in two cases of transient hemiplegia with recovery in two to two and a half hours. It is possible that general anæs-

thesia may mask transient paralysis or give protection against vasospastic reflex activity and thus inhibit hemiplegia.

Prolonged Unconsciousness. Prolonged unconsciousness can occur and was seen in two patients, both of whom were later diagnosed as having secondaries in the brain.

> In one, a man aged thirty-one, investigated for hemiparesis of slow onset, a general anæsthetic had been given and he was still unconscious six hours after return to the ward. Atropine gr. 1/100 (0.65 mg.) followed by neostigmine 2.5 mg. had been administered before leaving the X-ray department. Respirations were not depressed. Blood-pressure was 130/100, pulse regular. 40 ml. of 50 per cent glucose was given intravenously as an internal hydrocephalus was shown on the angiograms. A return to consciousness followed and no aggravation of the existing paresis was evident next day.

Ocular Complications. Ocular complications from vasospasm have occurred and Falls et al (1951) describe temporary visual loss with subsequent full recovery in two patients but severe optic neuritis and permanent loss of vision in a third case. We have not encountered this complication in our series.

CONCLUSIONS

These anæsthetics are not difficult but a knowledge of the technique and the risks involved means that the anæsthetist can take steps to prevent unnecessary harm resulting from what is, after all, only a diagnostic procedure and not a cure, and enables him to play his part in the treatment of complications when they arise.

I should like to thank Dr. R. R. Hughes for his kind permission to report this series of cases.

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JOHN SNOW, M.D., A REPRESENTATIVE OF MEDICAL SCIENCE AND ART OF THE VICTORIAN ERA

By Sir Benjamin Ward Richardson

(*Reprinted from* The Asclepiad *of* 1866)

The Victorian Faculty of Physic has produced no one man of commanding genius who has remained in medicine, practising the art. It has, however, produced many truly representative men who, in their combined labours, offer a magnificent result of work done and advancement made. Amongst these I should place in the first rank the late Dr. John Snow, and for this reason I bring forward here a sketch of his career for the student of the future.

John Snow was born at York, on June 15th, 1813. He was the eldest son of his parents. His father was a farmer. As a child he showed his love of industry, and increasing years added only to the intensity with which he applied himself to any work that was before him. He was first sent to a private school at York, where he learned all that he could learn there. He was fond of the study of mathematics, and in arithmetic became very proficient. At the age of fourteen he went to Newcastle-on-Tyne, as an articled pupil to Mr. William Hardcastle, surgeon, of that place. He had also the opportunities of studying at the Newcastle Infirmary. During the third year of his apprenticeship, when he was seventeen years old, he formed an idea that the vegetarian system of feeding was the true and the old; and with a consistency which throughout life attended him, tried the system rigidly for more than eight

years. He was a noted swimmer at this time, and could make head against the tide longer than any of his omnivorous friends.

At or about the same time that he adopted his vegetarian views, he also took up the temperance cause. He not only joined the ranks of the total abstinence reformers, but became a powerful advocate of their principles for many succeeding years. In the latter part of his life he occasionally drank a little wine, but his views on the subject remained to the end unchanged. He retained a strong faith in total abstinence, and a belief that it must ultimately become universal.

In 1831–32 cholera visited Newcastle and its neighbourhood, and proved terribly fatal. In the emergency Mr. Snow was sent by Mr. Hardcastle to the Killingworth Colliery, to attend the many sufferers from the disease. In this labour he was indefatigable, and his exertions were crowned with great success. He made also various observations relating to this disease, which proved to him of immense account in after-years.

He left Newcastle in 1833, and engaged himself as assistant to Mr. Watson, of Burnop Field, near Newcastle, with whom he resided for twelve months. Leaving Burnop Field in 1834–5, he revisited his native place, York, for a short stay, and thence to a certain half-inaccessible village called Pately Bridge, in Yorkshire, to act as assistant to Mr. Warburton, surgeon of that place. Eighteen months at Pately Bridge, with many rough rides, a fair share of night work, a good gleaning of experience, and, this sojourn over, our student went back again to York, to remain a few months, and to take an active share in the formation of temperance societies. In leisure days during this period it was his grand amusement to make long walking explora-

tions into the country, collecting all kinds of information—geological, social, sanitary, and architectural.

At last York must again be left, for the London student life was in view. In the summer of 1836 he set off from York to Liverpool, and, trudging it afoot from Liverpool through the whole of North and South Wales, turned London-ward, calling at Bath by the way, on a visit to his uncle, Mr. Empson, to whom, to the end of his life, he was devotedly attached. October 1836—eventful October—brought him to the "great city," and placed him on the benches of the Hunterian School of Medicine in Windmill Street; a school long since closed, and now as mythical as the mill which gave the name to the locality.

In October 1837 Mr. Snow began to take out his hospital practice at the Westminster Hospital. On May 2nd, 1838, he passed his examination, and was entered duly as a member of the Royal College of Surgeons of England. In October 1838 he passed the Apothecaries' Hall, and was now duly qualified in medicine. His student days were passed at 11, Bateman's Buildings, Soho Square.

At this time there existed in London a society (now the "Medical Society of London"), called the "Westminster Medical Society." It was a society which had long given encouragement to those junior members of the medical profession who might wish for a hearing at its meetings and debates. Mr. Snow was not the man to lose an opportunity such as this. I have often heard him say, both privately and publicly, that, upon his early connection with the "Westminster Medical," his continuance in London depended, and all his succeeding scientific success. When he first attended the meetings of the "Westminster Medical," he was very timid; and although he always spoke to the point, he found it difficult to obtain a favourable notice. At first nobody ever replied to what he said. After

a long time some grave counsellor condescended to refer to him as the "last speaker." A little later and somebody ventured to name "the last speaker" by his name. Then some one, bolder still, concurred with Mr. Snow; and ultimately Mr. Snow became recognized more and more, until the presidential honours were his own.

Frith Street, Soho Square, No. 54, was the house at which Mr. Snow, to use his own words, "first nailed up his colours." He removed there from Bateman's Buildings in September 1838. He bought no practice, nor exhibited any pretence, but a more thoroughly girded man for the world's encounter could hardly be conceived than he at this time. He took no wine nor strong drink; he lived on anchorite's fare, clothed plainly, kept no company, and found every amusement in his science books, his experiments, and simple exercise.

To fill up time till the money patients should come, he became one of the visitors of the out-patients of Charing Cross Hospital, and to many a representative of the great poor he extended a skill which would have been a blessing to the great rich. The librarian of the College of Surgeons' Library considered him a quiet man, who read closely, and was not too proud to ask for a translation when an original bothered him. All who knew him said he was a quiet man, very reserved and peculiar—a clever man, but not easy to be understood, and very peculiar.

The connection with the "Westminster Medical" led to Mr. Snow's first attempts at authorship. On October 16th, 1841, he read at the Society a paper on "Asphyxia and on the Resuscitation of New-born Children." The paper in full will be found in the *London Medical Gazette* for November 5th of the same year. The paper is remarkable for the soundness of its reasonings and the advanced knowledge which it displays. The object of the paper was

to introduce to the Society a double air-pump, for supporting artificial respiration, invented by Mr. Read of Regent Circus. The instrument was so devised that by one action of the piston the air in the lungs could be drawn into one of the cylinders, while by the reverse action the expired air could be driven away, and the lungs supplied with a stream of pure air from the second cylinder. There was also advanced, in the concluding part of the communication, the view that the cause of the first inspiration is probably the same as the second or the last, viz., a sensation or impression arising from a want of oxygen in the system. So long as the placenta performs its functions, the fœtus is perfectly at ease, and feels no need of respiration; but whenever this communication between the child and its mother is interrupted, at least in the later months of pregnancy, the child makes convulsive efforts at respiration similar to those made by a drowning animal.

On December 18th, 1841, Mr. Snow was again before the " Westminster Medical " with a very ingenious instrument which he had invented for performing the operation of paracentêsis of the thorax. The description of the instrument will be found in the *Medical Gazette* of January 28th, 1842.

In the *Medical Gazette* for November 11th, 1842, Mr. Snow published a note on a new mode for securing the removal of the placenta in cases of retention with hæmorrhage; and in the same journal for March 3rd, 1843, he communicated an essay on the circulation in the capillary vessels. The essay was selected and re-arranged from papers read before the " Westminster Medical " on January 21st and February 4th. We have in this essay an admirable sketch of the capillary circulation. He advanced, on this occasion, the idea that the force of the heart is not alone sufficient to carry on the circulation, but that there is a

force generated in the capillary system which assists the motion. He explained also the great importance of the cutaneous exhalation, and reasoned that in febrile states, accompanied with hot skin, the transpiration from the skin is in reality greater than it is in health.

Pushing on in the higher branches of his profession, and aiming always at the best, the degree of the University of London became a temptation, and *Mr.* became *Dr.* Snow on the 23rd of November, 1843, by passing the M.B. examination. He was enrolled in the second division on this occasion. On the 20th of December in the following year, he passed the M.D. examination, and came out in the first division.

The harass of London life by this time commenced to tell on Dr. Snow. He had suffered a few years previously from threatened symptoms of *Phthisis pulmonalis*, but took plenty of fresh air and recovered. He again became unhinged for work, and in the summer of 1845, was attacked with acute and alarming symptoms of renal disorder. His friend and neighbour, Mr. Peter Marshall, then of Greek Street, afterwards of Bedford Square, gave him his able assistance, and the advice of Dr. Prout and of Dr. Bright was obtained. In the autumn of 1845 he paid a visit to his old colleague, Mr. Joshua Parsons, at Beckington. From Beckington he went to the Isle of Wight, but soon returned to London and was elected Lecturer on Forensic Medicine at the Aldersgate School of Medicine, an appointment held till the school ceased in 1849.

There is no night without its morning. The eventful medical year of 1846 proved the turn of tide season for our struggling Esculapian. In this year the news came over from America that operations could be painlessly performed under the influence of ether.

The fact was just such an one as would at once attract

the earnest attention of Dr. Snow. It was a physiological, as well as a practical fact. It was rational in its meaning, and marvellously humane in its application. The question, once before him, was in a scientific sense his own. His previous experimental studies on respiration and asphyxia had prepared him for this new inquiry; he took it up for its own sake and not from any thought, at the time, of a harvest of gold.

The first inhalations of ether in this country were not so successful as to astonish all the surgeons, or to recommend etherisation as a common practice. The distrust arose from the manner in which the agent was administered. Dr. Snow at once detected this circumstance; and remedied the mistake by making an improved inhaler. He next carried out many experiments on animals and on himself, and brought the administration to great perfection. One day, on coming out of one of the hospitals—I am giving the narrative as he gave it to me—he met a druggist whom he knew bustling along with a large ether apparatus under his arm. "Good morning!" said Dr. Snow. "Good morning to you, doctor!" said the friend; "but don't detain me, I am giving ether here and there and everywhere, and am getting quite into an ether practice. Good morning, doctor!" Rather peculiar! said the doctor to himself; rather peculiar, certainly! for this man has not the remotest physiological idea. An "ether practice! If he can get an ether practice, perchance some scraps of the same thing might fall to a scientific unfortunate." Consequently, with his improved inhaler, Dr. Snow lost no time in asking to be allowed to administer ether to the out-patients of St. George's Hospital, in cases of tooth-drawing. Dr. Fuller, of Manchester Square, standing by, was surprised to see with what happy effects ether was administered when administered properly. A day or two afterwards, a major operation having to be

performed, and the surgeon, Mr. Cutler, not approving of the ether in the way in which it had previously acted, Dr. Fuller remarked on the superiority of Dr. Snow's mode of administering it; and the result was, that he was asked to give it on operating days. He did so with great success. He administered it also at University College with the same success. Liston, then the leading operator, struck with the new man, able as unaffected, took him by the hand; and from that time the ether practice in London came almost exclusively to Dr. Snow.

The new field once open, it were impossible but that he should cultivate it diligently. The Westminster Medical Society was often favoured with his communications and experiments on etherisation; and in the September of 1847 he embodied, in his first work, the whole of his experience up to that time. The work was remarkable for the care with which it was written, and the complete mastery of the subject which it conveyed.

What had been a mere accidental discovery, I had almost said a lucky adventure, was turned by the touch of the master into a veritable science. The book was beginning to be appreciated when the discovery of the application of chloroform threw ether into the shade, and the book with it.

Dr. Snow, though a man of great firmness when once his mind was made up, was always ready for new inquiry. Chloroform, therefore, was no sooner brought before the profession by Dr. Simpson, than he began to institute a a series of independent researches, and having satisfied himself personally as to the effects and greater practicability of chloroform, he at once commenced its use, and forgot sooner than most others his predilections for ether. In 1848, he commenced a series of experimental papers on narcotic vapours in the *Medical Gazette*, and continued them until 1851, when the *Medical Gazette* ceased to exist indepen-

dently. The papers on narcotics, in accordance with his other and earlier productions, were stamped with the evidences of profound and careful research, and still more careful deduction. I infer that they have been more talked about than read, for few people seem to be aware of the enlarged and original physiological arguments which they contain. Chloroform and ether are not alone discussed, but all narcotics. Narcotics are not alone considered, but various of the great functions of life. The records of a vast number and variety of experiments are here related, and an amount of information, original in kind, collected, which will always remain as a memorable record in the history of medical literature. But the great points in these papers are those in which the author enters on the physiological action of narcotics. Here appear the generalizations and insights into the relations of allied phenomena which mark the man of true power.

The year of the world's fair in London, 1851, may be considered a fortunate one for Dr. Snow. His affairs had taken a new turn, and the tide was fairly in his favour. He had a positive holiday, physical and mental. The harass of the professional struggle was over, the world was opening its eyes to his intrinsic merits; old friends, brought to the grand show in town, flocked around him, and all was well. He did but little that was new this year, except to write a characteristic letter to Lord Campbell, who was pushing on a Bill in the House of Lords, called the "Prevention of Offences Bill," in which a clause was introduced to prevent, by severe punishment, any attempt that might be made by any person to administer chloroform or other stupefying drug for unlawful purposes. Dr. Snow, believing that Lord Campbell was actuated in introducing this clause by the fact of certain trials having recently occurred for the offence of using chloroform unlawfully, and being him-

self convinced that, in two of the cases, one the case of a robbery in Thrale Street, the other, of a robbery attempted on London Bridge, the evidence against the prisoners, of attempting to produce insensibility by chloroform, was without any reason or possibility, he opposed the aforenamed clause in the Bill, on the ground that, if it became law, numerous frivolous and false charges would be constantly brought up against innocent people, or against guilty persons, but persons not guilty of the special charge laid against them, that, namely, of administering a volatile narcotic by inhalation. Knowing that weakness of human nature which leads a man, in the presence of all evidence, never to admit intoxication as possible in his own proper person, Dr. Snow felt that, in any case where an intoxicated person had been robbed, such persons might allege that he had been made insensible by narcotic vapour. The two cases specially noticed in his letter admitted readily of such interpretation, and were clearly not cases in which chloroform had been administered. Lord Campbell, on the receipt of Dr. Snow's letter, referred to it in very complimentary terms in the Lords, but intimated that the reasoning of the letter did not alter his determination.

In the year 1848 Dr. Snow, in the midst of his other occupations, turned his thoughts to the questions of the cause and propagation of cholera. He argued in his own mind that the poison of cholera must be a poison acting on the alimentary canal by being brought into direct contact with the alimentary mucous surface, and not by the inhalation of any effluvium. In all known diseases, so he reasoned, in which the blood is poisoned in the first instance, there are developed certain general symptoms, such as rigors, headache, and quickened pulse; and these symptoms all precede any local demonstration of disease. But in cholera this rule is broken; the symptoms are primarily seated in

the alimentary canal, and all the after-symptoms of a general kind are the results of the flux from the canal. His inference from this was, that the poison of cholera is taken direct into the canal by the mouth. This view led him to consider the media through which the poison is conveyed, and the nature of the poison itself. Several circumstances lent their aid in referring him to water as the chief, though not the only, medium, and to the excreted matters from the patient already stricken with cholera, as the poison. He first broached these ideas to Drs. Garrod and Parkes, early in 1848; but feeling that his data were not sufficiently clear, he waited for several months, and having in 1849 obtained more reliable data, he published his views *in extenso* in a pamphlet entitled " The Mode of Communication of Cholera." During subsequent years, but specially during the great epidemic outbreak of the disease in London in 1854, intent to follow out his grand idea, he went systematically to his work. He laboured personally with untiring zeal. No one but those who knew him intimately can conceive how he laboured, at what cost, and at what risk. Wherever cholera was visitant, there was he in the midst. For the time he laid aside as much as possible the emoluments of practice; and when even, by early rising and late taking rest, he found that all that might be learned was not, from the physical labour implied, within the grasp of one man, he paid for qualified labour. The result of his endeavours, in so far as scientific satisfaction is a realization, was truly realized, in the discovery of the statistical fact, that of 286 fatal attacks of cholera, in 1854, occurring in the south districts of the metropolis, where one water company, the Southwark and Vauxhall, supplied water charged with the London fæcal impurities, and another company, the Lambeth, supplied a pure water, the proportion of fatal cases to each 10,000 houses was to

the Southwark and Vauxhall Company's water 71, to the Lambeth 5.

There was, however, another fact during this epidemic, which more than the rest drew attention to Dr. Snow's labours and deductions. In the latter part of August 1854, a terrific outbreak of cholera commenced in and about the neighbourhood of Broad Street, Golden Square. Within two hundred and fifty yards of the spot where Cambridge Street joins Broad Street, there were upwards of 500 fatal attacks of cholera in ten days. To investigate this fearful epidemic was at once the self-imposed task of Dr. Snow. On the evening of Thursday, September 7th, the vestrymen of St. James's were sitting in solemn consultation on the causes of the visitation. They might well be solemn, for such a panic possibly never existed in London since the days of the great plague. People fled from their homes as from instant death, leaving behind them, in their haste, all which before they valued most. While, then, the vestrymen were in solemn deliberation, they were called to consider a new suggestion. A stranger had asked, in modest speech, for a brief hearing. Dr. Snow, the stranger in question, was admitted, and in few words explained his view of the "head and front of the offending." He had fixed his attention on the Broad Street pump as the source and centre of the calamity. He advised the removal of the pump-handle as the grand prescription. The vestry was incredulous, but had the good sense to carry out the advice. The pump-handle was removed, and the plague was stayed. It was my privilege, during the life of Dr. Snow, to stand on his side. It is now my duty, as a biographer who feels that his work will not be lost, to claim for him not only the entire originality of the theory of the communication of cholera by the direct introduction of the excreted cholera poison into the alimentary system; but, independently of

that theory, the entire originality of the discovery of a connection between impure water supply and choleraic disease. The whole of his inquiries in regard to cholera were published in 1855, in the second edition of his work on the "Mode of Communication of Cholera"—a work in the preparation and publication of which he spent more than £200 in hard cash, and realized in return scarcely so many shillings.

In 1856, he made a visit to Paris in company with his uncle, Mr. Empson, who having personally known the emperor many years, had on this occasion special imperial favours shown to him, in which the nephew participated. During the visit Dr. Snow lodged a copy of his work on Cholera at the "Institute," in competition for the prize of £1,200 offered for the discovery of a means for preventing or curing the disease. The decision of the judges has since been published, but with no notice of Dr. Snow's researches.

The Medical Society of London, reformed under that name in 1849–50, by amalgamation with the Westminster Medical, was at this time the principal scene of Dr. Snow's scientific exertions. In 1852, the Society elected him as Orator for the ensuing year; and at the eightieth anniversary of the Society, held on March 8th, at the Thatched House Tavern, he delivered an admirable oration on "Continuous Molecular Changes, more particularly in their Relation to Epidemic Diseases." He made no claim to the orator's gown; but the address was too forcible not to call forth the enthusiasm of the audience. He spent nearly twelve months in the preparation of this oration, in which he endeavoured to convey, in the most pleasing manner at his command, a broad view of his observations on the communication of certain spreading diseases. He advanced, on this occasion, the idea that the poison of intermittent

fever, and perhaps yellow fever, is carried direct, like the poison of cholera, into the alimentary system.

Two years after this event, having, meantime, passed the office of vice-president, the Society elected him to the highest honour it can confer,—to the presidential chair. He took his place as President, in his unassuming manner, on March 10th, 1855, delivering a short address. Throughout the year he carried out the duties of his office with great success. One of his presidential acts was peculiarly graceful. One evening, while presiding, Dr. Clutterbuck—then the father, or oldest member of the Society—came into the meeting. The venerable and distinguished old man, then long past his eightieth year, had lately been a stranger to the assembly, and was known but to few of the members. The President, as Dr. Clutterbuck entered the room, rose, and in a way that was irresistible in its simple courtesy resigned his chair to the veteran Esculapian. "It is near fifty years," said Dr. Clutterbuck with emotion, as he took the proffered seat, "since I last occupied this honourable position." At the next anniversary meeting, held on March 8th, 1856, Dr. Clutterbuck came to his last meeting, and to see his friend the President play also his last part in presidential duties. At the anniversary dinner on that same day, the President reviewed, in feeling terms, his own career in the professional strife, and expressed that his success in life had originated in his acquaintance with the Society.

In addition to the fellowship of the Medical Society, Dr. Snow belonged to the Royal Medical and Chirurgical, Pathological, and Epidemiological societies, and to the British Medical Association. The Medical Society, from its old associations, was, however, that in which he took the most active part. Next to this, the Epidemiological Society,

founded by the late Mr. Tucker, of Berners Street, claimed his regard.

The position which he took as an epidemiologist was original, and in opposition to the views of many eminent men who had, in matters relating to public health, considerable scientific and political influence.

He contended, in regard to true epidemic disorders, distinguished by specific symptoms, that they are due to a specific poison, which is propagated by certain fixed laws; which attains its progression and increase in and through animal bodies; which is communicated from one animal body to another; and, which is the same in its essence from first to last. This was his position, and he adhered to it. No mere emanation arising from evolution of foul smelling gases can, *per se*, according to his views, originate a specific disease, such as small-pox or scarlet fever; as well expect that the evolution of such gases should plant a plain with oaks or a garden with crocuses. The small-pox may occur over a cesspool as an oak may spring up through a manure heap; but the small-pox would never appear over the cesspool in the absence of its specific poison; nor the oak rise from the manure heap in the absence of the acorn which seeded it.

In 1855 Dr. Snow gave evidence before the select committee on the " Public Health and Nuisances Removal Bill," in which evidence he strove to convey the impressions condensed above. Feeling that he had not been correctly understood, he afterwards wrote a letter to Sir Benjamin Hall, in which he set forth the whole of his argument very distinctly and sensibly. He indicated in this letter that he was no defender of nuisances, but that whereas a bad smell cannot, simply because it is a bad smell, give rise to specific disease, so an offensive business conducted in a place where it ought not to be, should be proceeded against by ordinary

law as a nuisance, without applying to it the word pestiferous, or otherwise dragging in and distorting the science of medicine.

In relation to public health Dr. Snow contributed many other observations. In the first number of my *Journal of Public Health and Sanitary Review*, he communicated a valuable paper, previously read at the Epidemiological Society, on the "Comparative Mortality of Town and Rural Districts;" and, previous to his decease, he was busily occupied in investigating the question of adulteration of bread with alum. He made several analyses of different specimens of bread, but his papers merely leave a brief record of the fact, without any comments or results.

I return for a few moments to some further points connected with his researches on inhalation. In addition to his experiments with volatile narcotics, he carried out for a long time a series of inquiries with other medicinal substances, and administered many remedies by inhalation at Brompton Hospital during a period of twenty months. In 1851, he recorded the result of this experience at the Medical Society of London, and explained the modes of administering various agents. Some, as morphia and stramonium, were inhaled with the aid of heat; others, as hydrocyanic acid and conia, were inhaled at the ordinary temperature. The particulars of these experiments will be found in a short paper in the *London Journal of Medicine* for January 1851.

He continued steadily to investigate the effects of various volatile agents for the production of insensibility, performing a variety of experiments with carbonic acid, carbonic oxide, cyanogen, hydrocyanic acid, Dutch liquid, ammonia, nitrogen, amylovynic ether, puff-ball smoke, allyle, cyanide of ethyle, chloride of amyl, a carbo-hydrogen from Rangoon tar, a carbo-hydrogen coming over with amylene, and

various combinations of these. His grand search was for a narcotic vapour which, having the physical properties and practicability of chloroform, should, in its physiological effects, resemble ether in not producing paralysis of the heart.

First he ascertained the boiling point of the substance under investigation; then the point of saturation of air with the vapour at different temperatures; next the effects of inhalation of the vapour by inferior animals; and finally the quantity required to be inspired, with the air breathed, to produce insensibility. When he had obtained any substance which would produce insensibility favourably on animals, he pushed it, in one or two experiments, to its extreme in animals of different kinds. Then having produced death by the inhalation, both by giving rapidly a large dose, and by giving a small dose for a long period, he observed the mode of death, whether it occurred primarily by cessation of the heart, or by cessation of the respiration. If the agent seemed to promise favourably from these inquiries, he commenced to try it on man; and the first man was invariably his own self. His friends, knowing his unflinching courage in the ardour of his inquiries, often expostulated with him in regard to the risks he ran. It was of no avail. He felt the personal trial a duty, and he did it. I do not believe, as some have supposed, that these personal experiments had any effect in producing his early death; but it is certain that he underwent many risks in the performance of his investigations, and that he held his own life of least value when the lives of others were under consideration.

There is yet another trait in his character which I cannot but notice, and which I would respectfully commend to all physiological inquirers. While he held it as a necessity to use inferior animals for the purpose of experiment, he never

touched a living thing with the physiologist's finger without having before him some definite object; and never performed experiment on any animal without providing with scrupulous care against the infliction of all unnecessary suffering. The interests of humanity were, he thought, best advanced by the universal practice of humanity.

By his earnest labours Dr. Snow soon acquired a professional reputation, in relation to his knowledge of the action of anæsthetics, which spread far and wide, and the people, through the profession, looked up to him from all ranks, as the guide to whom to entrust themselves in "Lethe's walk." On April 7th, 1853, he administered chloroform to Her Majesty at the birth of the Prince Leopold. A note in his diary records the event. The inhalation lasted fifty-three minutes. The chloroform was given on a handkerchief, in fifteen minim doses; and the Queen expressed herself as greatly relieved by the administration. He had previously been consulted on the occasion of the birth of Prince Arthur, in 1850, but had not been called in to render his services. Previous to the birth of Prince Leopold he had been honoured with an interview with His Royal Highness the Prince Albert, and returned much pleased with the Prince's kindness and great intelligence on the scientific points which had formed the subject of their conversation. On April 14th, 1857, another note in the diary records the fact of the second administration of chloroform to Her Majesty, at the birth of the Princess Beatrice. The chloroform again exerted its beneficent influence, and the Queen once more expressed her satisfaction.

Inquisitive folk often overburthened Snow, after these events, with a multitude of questions of an unmeaning kind. He answered them all with good-natured reserve. "Her Majesty is a model patient," was his usual reply: a reply which, he once told me, seemed to answer every purpose,

and was very true. One lady of an inquiring mind, to whom he was administering chloroform, got very loquacious during the period of excitement, and declared she would inhale no more of the vapour unless she were told what the Queen said, word for word, when she was taking it. "Her Majesty," replied the dry doctor, "asked no questions until she had breathed very much longer than you have; and if you will only go on in loyal imitation, I will tell you everything." The patient could not but follow the example held out to her. In a few seconds she forgot all about Queen, Lords, and Commons; and when the time came for a renewal of hostilities, found that her clever witness had gone home, leaving her with the thirst for knowledge still on her tongue.

From the literary and medical history of Dr. Snow, let me turn for a few pages to his history personal as I knew him. He was of middle height, of somewhat slender build, and of sedate expression. His long life in comparative student loneliness had made him reserved in manner to strangers; but with private friends he was always open, and of sweet companionship. With his increased popularity he became less reserved to strangers, and in the last years of his life he so far threw off restraint as to visit the opera occasionally. But he moderated every enjoyment, and let nothing personal stand in the way of his scientific pursuits. He was the impersonation of order. He had his time and place for everything. He kept a diary, in which he recorded the particulars of every case in which he administered chloroform or other anæsthetic, with comments on the results of the administration, and hints as to the dangers avoided or chanced. He kept a record of all his experiments and short notes of observations made by his friends. He rose early, and retired early to rest—at eleven o'clock. He seemed, whenever he was waited on, as though he had

nothing in hand, and was always open to an engagement.

Anything and everything of scientific interest that arrested his attention aroused his enthusiasm and his desire to be of use. When I was living at Mortlake, he would run down, on request, after his day's duties were over, to a *post-mortem*, to see a poor patient, or to take part in an experiment, returning as cheerily as though he had received the heaviest fee. This is but one example of his kindly nature.

He laid no claim to eloquence, nor had he that gift. A peculiar huskiness of voice, indeed, rendered first hearings from him painful; but this was soon felt less on acquaintance, and the ear once accustomed to the peculiarity, the mind was quickly interested in the matter of his discourse, for he always spoke earnestly, clearly, and to the point. In the Societies he spoke very often, and gave expression to views, on which he had spent great thought, with a generous freedom which, in so far as the fame of his originality was concerned, had been better held in reserve. It had been better, that is to say, for him to have carefully elaborated some of his views in the closet, and published them fully, than to have sent them forth in the hurry of debate. Had he lived, he would possibly have collected many stray labours thus put forward, and have given to them the mature consideration which they deserved. One of his views, on which he would have bestowed great attention, refers to the origin of various morbid growths, such as cancer. He believed that these morbid formations are all of local origin; that they arise in the parts of the body where they are found, from some perversion of nutrition; and that the constitutional effects are secondary to, and dependent on, the local disorder. He made many observations on this important subject, notices of which are to be found scattered, here and there, in the proceed-

ings of the Medical Society of London, but no connected record was ever completed.

His private conversation was both instructive and amusing; he was full of humorous anecdotes, which he told in a quiet and irresistibly droll style.

His replies, when under the fire of cross-question, were ready and common-sense. Once, as we have already told, he observed that sulphuric ether is safer than chloroform. "Why, then," said a listener, "do you not use ether?" "I use chloroform," he resumed, "for the same reason that you use phosphorus matches instead of the tinder box. An occasional risk never stands in the way of ready applicability." On another occasion, after one of the meetings of the "Medical Society," when the subject of a specific cholera cell had been under debate, some one asked him, as a poser and rather ironically, where he thought the first cholera cell came from? "Exactly," he replied, with a shrewd look. "But to begin, do you tell *me* where the first tiger or the first upas tree came from; nay, tell me where you came from yourself, and I will then tell you the origin of the first cholera cell, and give you the full history of the first case; but I want a model before I venture on the description of ultimate facts."

As an author his style was plain, clear, and smoothly elegant. His argument was always carefully studied and carefully rendered. He sent manuscript to the printer which required scarcely a letter of correction. Both in writing and speaking he made the expression of truth his first business. Neither provocation nor temptation could ever lead him aside from that principle. His readings were select. He chiefly read scientific works, old and new. He had great relish for some of the old medical writers—the masters in physic. He had read Bacon, but agreed with Harvey's criticism that Bacon wrote science like a lord

chancellor. He had a notion that there had been a history long previous to any we know of from existing records, in which the sciences generally had risen to a greater perfection than they are at this present. His conversance with Sprengel's "History of Medicine" had possibly led him to this opinion. He was fond of general history also, but studied it little. He never read novels, because the hours devoted to them were, he felt, hours thrown away. At the same time he enjoyed as much as any man ridiculous life-pictures naturally cast. When he came to see me, and leisure was with us, I often read to him some of the more amusing passages from Dickens and Thackeray, or from one of the older writers, as Swift. It was a new world to him, and provoked great fun. He would ask to have passages read over again, that he might better realize the conception. He himself observed human character shrewdly, and described it in its humorous phases so well that if he had written as he related he would have ranked as one of the great humorists of the age.

He thought severely of the reviewer's art, and would never of late review any book critically. If a book were good, it carried the review of its own merits. If it were bad, it were better left untouched. He, at all events, with so much original work before him, could not stop to criticize his compeers or their transactions. Let the dead bury their dead; he must march with the living while life gave power.

He admired art, and felt real pleasure in advancing it. He enjoyed innocent recreations, and was ever at home in the family circle. He had his regrets that he had never married, the fates had been against him permanently on that score. He loved the prattle and gaiety of children. When he went to court, arrayed in his court suit, nothing connected with the event delighted him so much as the say-

ing of the child of a friend, who, on seeing him start, with his sword and flattened hat, held up her hands, and exclaimed, "Oh! isn't Dr. Snow *pretty*, mamma." The idea of being considered pretty roused in him quite a new and droll sensation, which he could not help repeating as a rare incident in a courtier's career. The anecdote is simple, but it gives a good idea of the genial and gentle nature of the man.

It has been shown that the tendency of Dr. Snow's mind for philosophical pursuits led him away in some measure from the practical drudgery of professional life. From this fact it has been too hastily inferred that he was therefore, in the common parlance, "not a practitioner." Those who knew him as a practitioner, and had reaped the advantage of his assistance in cases of doubt or difficulty, had a very different opinion. These, with one accord, spoke of him, as having been, without any ostentation, one of the soundest and most acute of our modern physicians. He had great tact in diagnosis; an observant eye, a ready ear, a sound judgment, a memory admirably stored with the recollection of cases bearing on the one in point; and a faculty of grouping together symptoms and foreshadowing results, which very few men have possessed. For my part, I can bear truthful testimony to his eminent qualities as a practitioner, and to the fact that his philosophical labours only served to render him more intelligent and profound in matters relating to diseases and their treatment.

And, when the opportunity offered for obtaining remunerative practice by the exercise of true scientific skill, Snow showed himself, both in act and industry, competent for success. He soon overcame all difficulties, and managed by his frugality to lay in store for a rainy day for himself, and to help such friends as needed. Many rumours as to the extent of his gains abounded which it is right to correct.

His largest income was £1,000 a year; it never exceeded that sum. For this he administered chloroform or other anæsthetic about four hundred and fifty times annually, taking an average of ten years preceding his death. In many cases his services were gratuitously supplied.

In his private relations Dr. Snow was a man of the strictest integrity and purest honour. The experiences of life, instead of entwining round him the vices of the world, had weaned him from the world. Without any pretence, maintaining no connection with sect or party, he carried out a practical religion, independently of any hypothesis or abstruse profession, which few professors could approach. A child of nature, he knew no way of recognising the Divine influences so purely as in silent and inexpressible admiration of those grand external phenomena which each moment convey, to men of his character, the direct impression of a Power all-present and revealing itself for ever.

We approach the end. In the midst of his success, when medicine most valued him and his hand was most powerful, he stood one day in his mental strength, and the next day fell. Death found him at his duty.

On the morning of June 9th, 1858, while at work at the MS. of his last book, "On Chloroform and Other Anæsthetics," he was seized suddenly with paralysis just as he had written the word "*exit*;" and on June 17th, at 3 p.m., he slept the euthanasia. He was buried in Brompton Cemetery, and over his grave a few of us who knew him best erected a simple memorial.

For John Snow, as a representative man of medicine of the Victorian era, we may claim the poetic thought, less the poetic expression, combined with industry, perseverance, and the courage to express his own opinions

boldly when founded on what he honestly felt to be the truth, and, if not the whole truth, nothing but the truth.

He had a patience that was inexhaustible, a devotion for labour unsurpassed, and a slow but sure and reliant comprehension and comprehensiveness which were not easily seen because of their extent. He combined with a stolid firmness distinctively Saxon a rare talent for penetration into obscure problems, for casting aside objects which are coincident or accidental, and for seizing determinately the realities for which he sought.

These attributes, if they do not constitute genius, consecrate life; and, represented by and through a man, a family, or a nation, make the choicest history of the grandest eras.

Brit. J. Anæsth. (1952), **24**, 292.

EMINENT ANÆSTHETISTS, No. 7

ARTHUR E. GUEDEL

By RALPH WATERS

BEFORE the first World War the number of true specialists in anæsthesia among doctors of the U.S.A. could be almost counted on the fingers of one's two hands. In March of 1918, one of these (Leslie Burwell of New Rochelle, New York) reported for duty at the Medical Headquarters of an American unit at Vittel in the Vosges, France. Upon his insistence that he wished to be assigned to work for which he was particularly fitted, the medical officer in command said, "You will have to see Guedel. He runs the Anæsthesia in this region. He blows in here every day or two, like a wild Indian, on a motorcycle. Wait for him." Sure enough, the next afternoon, with a roar and a put-put the motorcycle arrived in a cloud of dust.

Burwell's curiosity, as to how an anæsthetist could function on a motor-bike, was soon satisfied. The several hospitals in the neighbourhood could be visited frequently only by such means. The scarcity of anæsthetically minded medical officers had made it necessary to assign non-professional, inexperienced persons to duty as anæsthetists. The manner of teaching and directing such personnel under these circumstances is an illustration of the amazing versatility and resourcefulness of Arthur Guedel. He was forced to devise not only simple methods of teaching these willing though inexperienced people but also quick and reliable ways of checking the accuracy and safety of the dosage of ether which they were able, as a result of his teaching, to maintain in the operating rooms of the several

hospitals. The difficulties which Guedel surmounted during the first World War were of immense benefit to military surgeons and soldier-patients, it is true, but of what greater value were his experiences there to all the rest of us—teachers and pupils alike—all over the world! He insisted that during ether anæsthesia movement of the patient's eyeball was a sign which could be checked quickly and which the enlisted-man technician could observe readily and reliably. How often since, have we older teachers found the observation valuable, and even essential, in trying to help medical students and young physicians safely to administer anæsthetics. Guedel's chart of physical signs of ether anæsthesia was born in the military hospitals and while riding army motor bikes over the rough roads between them. I presume we might even say that the book, later published by Macmillan, as *Inhalation Anesthesia, A Fundamental Guide*, had its foundation built in Guedel's mind in the military hospitals and along the shell-shattered roads of France, during the first war.

Arthur Guedel is a Hoosier in origin and a genius by natural endowment. " Hoosier " is a nickname, in America, for many of our distinguished citizens who come from the state of Indiana. He was born in 1883 and graduated from the Medical School of the University of Indiana in 1908. The versatility of his interests and the originality of his thoughts were evident in the first years of his medical practice. But none of his valuable medical contributions, nor all of them together, can illustrate his protean capabilities.

In his younger days, his 15 stone of bone and muscle was perfectly co-ordinated for action. An athlete of the first order, he swam with endurance and was adept in the manly art of self-defence, yet no physician I have ever known had the delicate artistic co-ordination of the smaller

muscles that was his. He played the organ and piano with the skill of a natural artist. Many of the pieces of anæsthetic apparatus which have come from his hands bear witness to this delicacy of touch. How rarely do we find in the same individual such command of execution combined with originality, imagination, and critical thought. Not only could Guedel bring music from the keyboard but he could compose the music which fitted the occasion. One of his strongest assets, in writing, in lecturing, and in conversation, was his use of the pertinent story—of the perfectly illustrative case. Like every anæsthetist with original thoughts and a desire to learn, Guedel has made mistakes. But, unlike so many of us, he has *used* mistakes, unusual and unexpected happenings, as food for thought, as a basis for personal and professional advancement and to the benefit of his pupils and associates. His lectures and conversation were much more likely to be sprinkled with the stories of the case that nearly died than of the one that paid the large fee, and always a lesson was taught or material left in one's mind for future consideration and discussion.

It was my misfortune not to have enjoyed Guedel's friendship until after the first World War. Although we were of the same age, he graduated from medical school four years before I did and had developed one of his most important contributions to anæsthesia to the point of practical application before I had acquired a medical degree. The first volume of the *American Year Book of Anesthesia and Analgesia*, edited by F. H. McMechan, was published in 1916. To it Guedel contributed a resumé of his work on analgesia up to that time. The first of his papers referred to in the review was "Nitrous Oxide-Air Anesthesia Self Administered in Obstetrics," published in *The Indiana Medical Journal* for October 1911. Since he was ever excessively conservative regarding premature publication,

this meant that considerable work had been done with analgesia at least during 1910 or earlier. This article in the *Yearbook* is a classic. Unfortunately, it has received too little notice even to the present. Not only does it contain the basic principles of mixing nitrous oxide with air or with oxygen to produce analgesia and the advantages of self-administration of such mixtures, but included is an early example of the author's superb command of the methods which he has always used so effectively, of classification and diagrammatic representation as a means of clarification in writing and teaching. Nine charts are included which analyse, for the first time so far as I know, the variations in type of uterine contractions that occur in different women during labour. Superimposed upon these simple diagrams are representations of the necessary concentrations of gas and the time factors which he had found important in relieving pain during parturition.

Many of us who have done some teaching and writing find that, as time passes, we often regret what we have said —have to "eat our words," as the saying goes. In 1938, in response to an inquiry from Madison, Guedel wrote as follows regarding nitrous oxide in labour:

> Self administration of nitrous oxide in labor is O.K. I told you that twenty some years ago. However, I do not like the idea of strapping a mask on the patient's face. There is too much danger of aspiration of vomitus. And even of asphyxia if the gas mixture goes wrong. Before I stopped doing obstetric anesthesia I had gone to the old McKesson machine because we had one at the hospital. I later developed a spring release mask for the Heidbrink but did not like it as well.
>
> For a number of years I spent a lot of time telling the patient just what to do and how to do it. Later I got tired of telling and there developed for me the best technique that I found. I would push the gas machine up to the patient, set the oxygen for twenty to thirty per cent and tell the patient to take as much as she wanted whenever she wanted it. For the first twenty minutes or half hour they would be taking it for most of the time whether they needed it or not. But they would do that anyway under the

> " Telling " system so it did not matter. After they had become sedated by the N_2O—after twenty minutes or half an hour—they would sleep between pains, awakening at the beginning of the pain. They would then put the mask to their face and breathe like the devil for a few breaths—six to twelve—and go to sleep until the next pain. I would let this go on for hours, in some cases up to the point of actual delivery, when I would take it over. They would take care of their own anesthesia better and more safely than I could do it for them. After it was all over —the next day—they would invariably report that they were in labor but a short time. The hours were not noticed and they were happy. Keep the oxygen up. Don't strap the mask to their face. I used to strap it to their hand with adhesive tape so that they could find it easily when they wanted it. And don't pay too much attention to them.

This quotation illustrates very well two traits characteristic of Guedel. The first is that his early observations and opinions are apt to be checked carefully before expressing them, so that they need not be withdrawn later. The second is that his tendency, as time goes on, is towards practical simplification rather than towards more complication of methods and concepts. I doubt that anyone has added much of fundamental significance to the subject of the relief of pain in labour by inhalation, since Guedel's article in the 1915 *Yearbook*. It is to be regretted that it is not universally available in modern libraries.

From the end of the war until I moved to the University of Wisconsin in 1927, I met Guedel occasionally at anæsthetists' meetings and we exchanged infrequent letters. Our first discussions were concerned with his plans to include in his chart the physical signs of ether anæsthesia, the observation of Albert Miller of the progressive paralysis of respiration that takes place as anæsthesia becomes more profound; first the intercostal musculature and finally the diaphragm.

Later our common interests in the techniques of carbon dioxide absorption and of endotracheal intubation served to increase the frequency of letters passing between us.

After I joined the faculty at Wisconsin, our correspondence became active, our friendship real, and visits between us frequent. From 1925 to 1945, there was an average of several long letters a month. For my own part, they were all letters dictated to the secretary. While Guedel was officially connected with the Medical School in Indianapolis until he moved to California in the summer of 1928 and again with one of the medical schools in Los Angeles soon after going West, he depended upon private practice of anæsthesia in both places for his income and acted always as his own typist. As I re-read those letters now, I am impressed with the mere mechanical labour that was involved for him to keep up such a correspondence, writing often late at night after tiring hours in the operating room, in contrast to the help and convenience I enjoyed of a secretary available at all times.

During my recent re-examination of these letters, it is brought home to me more emphatically than ever how much, not only the Department of Anesthesia at Wisconsin, but American anæsthesia in general, owe to Arthur Guedel. The fact that he was the first outside the British Isles to receive the Hickman Medal (1941) testifies to such appreciation outside the U.S.A.. To me, he has been a wise adviser and a true personal friend. To both the department at Wisconsin and me he was, during 20 years, a valuable critic, and a master of argumentation and of unmerciful and inconsiderate frankness, when he believed we needed that treatment. But throughout all a wonderful and loyal friend at the times when loyalty and friendship really counted. The arguments about methods of teaching, or conducting research, of publication, and regarding experiences with new drugs and new techniques, were all subjects of hot debate throughout the twenty years; and every publication from the Department of Anesthesia

at Wisconsin was better for the critical comments of Guedel.

For many years his motto was, "Maintain Flying Speed," taken from the pilot of the time whose altitude began to fail as his forward progress diminished. But the letters I have just re-read come to a point where speed seems not so important. Here is one illustrative quotation, "There is a mighty small line between contentment and lazyness and tonight I am a bit over-contented at least." A little later he quotes a friend, "What the hell are you working for? A good obituary?"; and may I add one more quotation from these wonderful Guedel letters I have been reading? "It hurts a fellow some to see himself being slipped to the outside—but I am feeling more and more that, if he has good sense, he will slip himself clear out of it and pass the time doing something else—something entirely different." Aimed directly at me? I think so. We are now both retired and no longer write the heated, argumentative, contentious, and sometimes "scurrilous" letters regarding anæsthesia that pleased us for so many years. I believe we are no less happy because of retirement.

It has been said "If a man loves dogs he will love mankind". It is true of Guedel. The first dog that was subjected to closed endotracheal anæsthesia under water in his laboratory at Indiana was named "Airway" and shipped to my children in Madison because the Guedel family was already blessed with two dogs and "he is such a lovable mut." A sensitive man of intense personal likes and dislikes, with a "quick temper" and prompt expression of it; his intimate friendships have sometimes begun with a brief quarrel. He has been quick to admit his own fault and sincere in efforts to undo a real or fancied wrong. To friends, students, and family alike, kindness and generosity

have characterized his attitudes, often to his own disadvantage.

An appreciation of the humour of situations and an inimitable manner of expressing it, has stayed with him through happiness and adversity. No physician's family I have ever known enjoys a happier relation with father and husband.

The Guedel residence in Los Angeles has for years been a shrine visited by anæsthetists from far and near. Whether they are well or ill, whether in mood for visitors or in black despair—good will, hospitality and helpfulness shine forth from the home of Florence and Arthur Guedel.

FROM THE MORBIDITY CONFERENCE

EXPLOSION HAZARDS

IN THE COURSE of servicing an anæsthetic machine, the valve of a newly fitted oxygen cylinder was turned on in order to check the latter's contents on the pressure gauge. The action was followed by a flash and an explosion. Subsequent inspection of the machine showed that the oxygen rotameter tap was closed, that the rubber tubing connecting it to the reducing valve had burst and was charred internally; the reducing valve was scorched, its internal parts having melted. The recently filled ether bottle of the machine remained intact although only some six inches away from the seat of the explosion.

It seems probable that the cause of the explosion was a sticking reducing valve which, suddenly working free, momentarily admitted oxygen under high pressure to the rubber tubing. No outlet for the gas having been provided, it may be assumed that the pressure in the tubing rose very rapidly and generated heat; the combination of oxygen, heat and pressure causing the rubber to burn at a rate which almost instantaneously reached explosive velocity. The force of the explosion fortunately blew out the primary fire and failed to start a secondary conflagration.

Had the rotameter tap or the oxygen by-pass valve been open when the cylinder was turned on, it is possible that no damage would have resulted from the (presumed) defect in the reducing valve. It is also possible that the rubber tubing would have blown free from its connections, without causing an explosion, were it not for the fact that it was retained in place by metal bands.

The photograph (figs. 1 and 2) shows the coat and rub-

FIG. 1

FIG. 2

ber apron worn when the explosion occurred, and which limited the wearer's injuries to flash burns of the hand and abdomen.

This incident is reported because it illustrates the wisdom of opening up a low pressure circuit *before* turning on any high pressure valves which feed it.

A similar, although less serious, incident happened in another hospital. In preparation for a night emergency a nurse turned on the oxygen cylinder to have the machine ready for the anæsthetist's arrival. Flames immediately escaped from the top of the reducing valve and, within a few seconds, the surgeon, who was in the theatre, turned off the oxygen and the flames subsided. The oxygen by-pass was not turned on before opening the cylinder and a charred diaphragm in the reducing valve was the only result of the fire.

INADVERTENT OVERDOSAGE OF ETHER

A forty-five-year-old patient was brought to the theatre for an emergency abdominal operation. Anæsthesia was induced with thiopentone 500 mg. (2.5 per cent solution) and intubation carried out after gallamine triethiodide 100 mg. Anæsthesia was maintained on the closed circuit of a Boyle's machine, using the Coxeter-Mushin absorber and assisting the respiration. A flow of oxygen and nitrous oxide, one litre of each, was given to the patient, with the ether container of the Coxeter-Mushin circuit turned on mark $\frac{1}{4}$. After approximately ten minutes the ether was turned off and anæsthesia continued with a fifty per cent mixture of oxygen and nitrous oxide only.

After fifteen minutes it was noticed that the patient's

pulse was weak and slow and his pupils dilated. Respiration had to be controlled. The patient's colour was satisfactory.

Because it was considered that the patient was in peripheral circulatory failure the operation was stopped, the table put in the Trendelenburg position and the lungs inflated with pure oxygen.

A strong smell of ether was noticed and on investigation it was found that, although the ether container was turned off, the inside of the valve had not moved together with the outside and was full open.

The ether container was then emptied and subsequent ventilation of the patient with oxygen improved the condition markedly. The operation was proceded with under nitrous oxide-oxygen anæsthesia. Recovery of the patient took a long time but was uneventful.

Further investigation showed that a loose screw on the outside of the ether container caused the discontinuity between the outer ether concentration indicator and the inner valve. The pin ensuring correct alignment between the indicator and the valve and spindle was missing. How this came about has not been ascertained.

This case was of unusual interest because on the previous day a patient had remained in prolonged respiratory arrest following operation, when no ether had been used and the anæsthesia had been a relaxant-thiopentone-nitrous oxide combination. The patient had been put into a Drinker apparatus and had recovered fully, but a smell of ether had been suspected in the expirations and no explanation had been forthcoming!

Had the anæsthetists concerned taken the precaution of smelling the gases they were delivering before starting these cases, much trouble and anxiety would have been avoided.

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A NEW APPARATUS FOR INTERMITTENT PULMONARY INFLATION

By J. R. ESPLEN

Liverpool Thoracic Surgical Centre

THE AINTREE Respirator is designed to provide automatic pulmonary ventilation for the thoracic surgical case when apnœa is a feature of the method of anæsthesia.

The problem at the beginning was to develop a mechanism that would:

1. Actuate the breathing bag of an anæsthetic apparatus mechanically, and produce a type of ventilation similar to that customarily provided by hand.
2. Be governed by the response of the lung to inflation, rather than force respiration to follow a rigid pattern.
3. Operate satisfactorily at inflation pressures of 10 cm. of water and less.
4. Rapidly disperse the positive pressure used to produce inflation and so facilitate complete expiration.
5. Cease to operate, or provide some warning, if respiratory obstruction should develop.

The mechanism to be described has been found to meet the first four of these needs satisfactorily, and to some extent it fulfils the fifth requirement.

For descriptive purposes the apparatus may be considered to consist of two parts, which are (i) a glass bottle, or pressure chamber, containing a breathing bag that can

be connected to the anæsthetic circuit, and (ii) a valve mechanism which effects rhythmic compression and release of the breathing bag by alternately generating and dispersing an air pressure within the bottle.

The Pressure Chamber (Fig. 1).

This is a dispensary aspirator bottle (6) large enough to contain a one-gallon breathing bag (7).

The bottle is closed at the top with a rubber bung, through which passes the limb of the three-way tap (2) to which the breathing bag is attached.

By turning the tap, the operator can connect an extension (1) from a Waters' cannister, or other anæsthetic apparatus, to the hand-operated breathing bag (5) or to the bag in the bottle.

A small leak-way (3) channelled in the seating of the tap keeps the hand-operated bag full in readiness for use.

An outlet (4) at the base of the three-way tap connects the automatic breathing bag with a manometer (9) and with a self-regulating expiratory valve (8).

The manometer both records pressure changes in the anæsthetic circuit and serves as a safety valve, limiting the maximum pressure that can be applied by the machine to 30 cm. of water. It is put out of circuit when the tap is turned to the hand control position.

The self-regulating expiratory valve controls a one-way communication which leads from the breathing bag to a point in the system that is, in effect, open to the atmosphere during the expiratory phase of the respiratory cycle. The valve permits any excess of anæsthetic gas to escape, thus preventing the breathing bag from becoming distended and causing it to assume a constant volume at the end of each expiration.

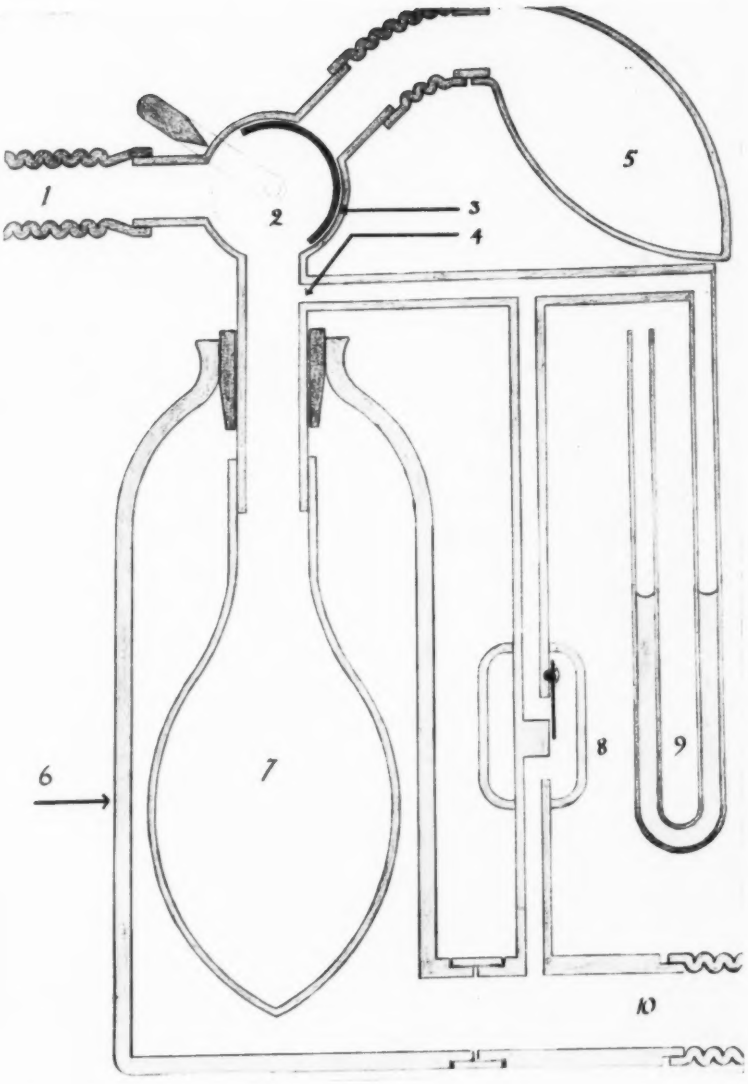

FIG. 1
The Pressure Chamber.

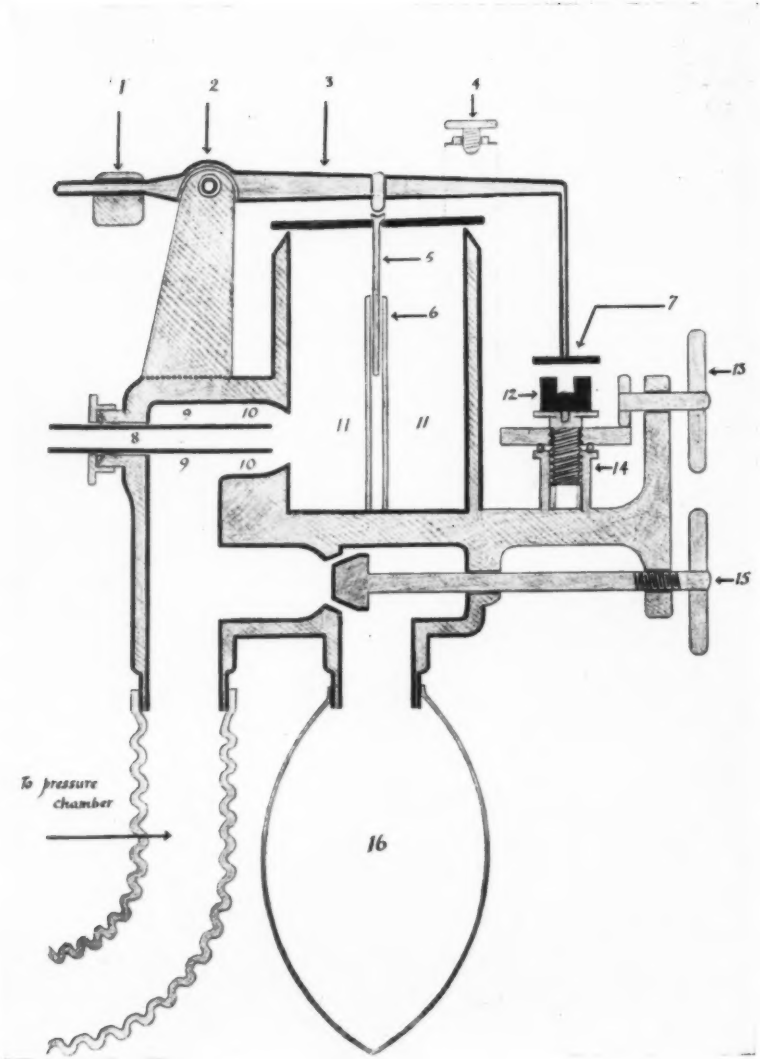

FIG. 2
The Valve Mechanism.

A connecting tube (10) joins the opening at the bottom of the bottle to the valve mechanism.

The Valve Mechanism (Fig. 2).

The valve is worked by, and controls, a current of compressed air.

An air supply of approximately 20 litres a minute is required, delivered at a pressure of 100 mm. Hg at the machine inlet. At Aintree preference is for the source of supply to be external to the operating theatre.

Air enters the machine through an induction tube (8), its rate of admission being controlled by a tap which incorporates a non-return valve of orthodox design. The tap is not shown on the plate.

From the induction tube, the air passes into a cylinder (11) which is sealed off at the bottom and closed at the top by a light metal disc. Under pressure this disc can be displaced outwards against the thrust of a cross-beam (3).

A pin (5) and guide (6) keep the disc-valve centred in the cylinder axis.

The cross-beam is pivoted at (2) and is balanced by a counterweight (1). A small metal plate (7), dependent from the end of the beam, is however within the field of a permanent magnet (12), and the pull of the magnet on the plate is transmitted by the beam as a downward pressure on the disc-valve.

Being at first unable to escape from the closed cylinder, the air stream reverses its direction of movement, and passes through the annular space (10) surrounding the induction tube to enter the pressure chamber.

The pressure in the cylinder and chamber rises, and, when it has reached a predetermined level, the upward thrust of the disc-valve offsets the downward thrust of the

beam. The beam then swings upwards, the disc-valve blows open, and the phase of deflation begins.

The pressure at which the valve opens, which corresponds to the pressure applied to the lung, may be varied by raising or lowering the position of the magnet in relation to the metal plate (7). This is effected by operating the control (13) of a simple screw gear (14).

During deflation the incoming air stream is no longer turned upon itself, but passes straight through the cylinder, which it leaves by the open valve. In its escape it performs work. Firstly, its impact on the under surface of the disc-valve neutralizes the weight of the valve, and secondly, its forward momentum creates a venturi effect which produces a negative pressure zone (9) around the induction tube. This negative pressure is just sufficient to overcome the inertia and resistances of the gas system and facilitate expiration.

The remaining feature of the valve mechanism is the buffer bag (16) and its control (15). The former is a two gallon rubber bag. Its function is to absorb or damp down pressure waves of extraneous origin, such as those produced by the surgeon when manipulating the lung, which might cause premature "tripping" of the valve and consequently disturb the respiratory rhythm. The buffer bag may be regarded as a variable capacity which is fed through a variable resistance.

Whilst the buffering effect is largely independent of the degree of opening of the control valve, closing the valve increases and opening it reduces the frequency of the respiratory cycle. The buffer bag control valve is therefore used in practice to regulate the rate of respiration, and permits any rate within a range of from eight to thirty respirations a minute to be selected.

Variations in the length of inflation relative to expiration may be obtained, without significant alteration of the respiratory rate, by increasing or reducing the air flow to the machine. Increasing the air flow shortens the inflationary and lengthens the expiratory phase of the cycle (fig. 3), whilst a reduction in the air supply has the opposite effect (fig. 4).

FIG. 3

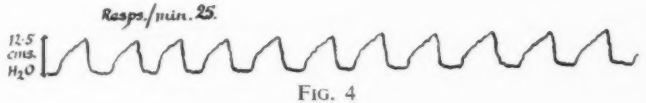

FIG. 4

The pressure held in the lung during expiration may be controlled by altering the clearance present between the beam and its stop (4). Reducing this clearance raises the residual pressure by limiting the extent to which the valve can open and imposing a resistance to expiration. The lowest residual pressures, which are difficult to measure accurately and which vary from case to case within an apparent range of minus half to plus two centimetres of water, are obtained by increasing the clearance to the working limit; an excessive clearance resulting in the valve remaining open at the end of expiration, and stopping the machine.

Should an obstruction to respiration develop the capacity of the anæsthetic system alters, and the fact is indicated by the machine "chattering" and failing to build up an inflationary pressure, or by a departure from the

set respiratory rate. The type of response depends on the degree of obstruction present and the setting of the machine, which is most sensitive to alterations of capacity when a fairly fast respiratory rate is being employed and the buffer bag control is nearly closed. When the latter is fully open the machine is insensitive.

Alteration of the respiratory rate or irregularities of rhythm also occur when anæsthesia becomes too light or when curarization is inadequate, and these signs sometimes appear several minutes before the insufficiency is obvious to the hand or eye. Some experience in the use of the machine is necessary before minor variations in rate and rhythm can be detected readily and their significance interpreted.

Except for experimental purposes the machine has not been employed to "assist" spontaneous respiration, but consideration of figures 1 and 2 will show that the pressure changes of voluntary respiration will "trigger" the valve and set the pace for the machine. It seems doubtful whether a machine can ever assist respiration in an entirely satisfactory manner, because it cannot anticipate inspiration. It can only respond to the pressure change which is itself a sequel to the inspiratory act, and endorse, so to speak, a *fait accompli*. Patients emerging from apnœa have frequently been observed to resume spontaneous respiration in perfect time with the machine, and to breathe freely with it for considerable periods, until some stimulus precipitates a cough and breaks the synchrony of the rhythm.

CLINICAL TRIALS

Since its introduction at Aintree Hospital, Liverpool, in September 1949, personal experience has been gained

in the use of the respirator in the course of anæsthesias for the following 480 operations: —

Pneumonectomies (for tubercle)	78
Lobectomies (including segmental resections of lung, for tubercle)	292
Thoracoplasties	77
Pericardectomy	1
Cholecystectomy	1
Nephrectomy	1
Appendicectomies	2
Rib resections, etc.	28
	480

The cases in the series were not truly consecutive because very occasionally patients were presented for operation whom it would have been clearly unwise to respire by machine.

In no case in the series, so far as can be ascertained, has the disease extended to a new area of the lung, suggesting a "spill-over", whilst the incident of post-operative lobar collapse seems to be about the same whether the patient is respired by hand or by machine.

Three deaths occurred within six weeks of operation, and in one case the anæsthetic may have contributed to the outcome.

Technical Procedure.

In the theatre the patient was connected to the machine as soon as he had been positioned for operation. A rate of 12 to 18 respirations a minute with an inflation pressure of 15 cm. of water provided adequate ventilation at this stage in the majority of cases, but after the pleura had

been opened it was always possible to reduce the pressure, sometimes to 7 cm. of water, the ease with which inflation could be carried out varying considerably from case to case.

The longer the duration of operation the more important it appeared to be to ensure (i) that the inflation pressure was kept no higher than was necessary to maintain a reasonable tidal volume, (ii) that an adequate expiratory pause was allowed, and (iii) that the pressure in the breathing circuit fell to as near the atmospheric level as possible during the expiratory phase (Cournand et al, 1948). Figures 5 and 6 show a variety of tracheal pressure curves taken from cases ventilated by the machine. Figure 7

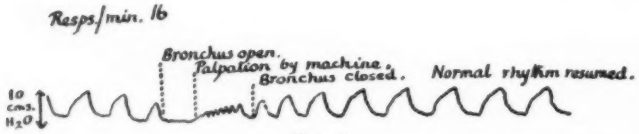

FIG. 5

FIG. 6

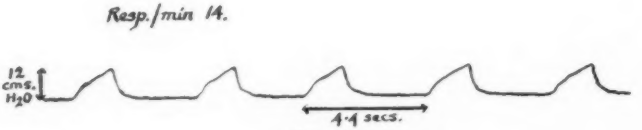

FIG. 7

represents the respiratory pattern used in the case of a woman in failure from constrictive pericarditis. This tuberculous patient was cyanosed and made dyspnœic by the effort of feeding; a tic-tac rhythm was present, her liver was enlarged, and she had collections of fluid in her chest

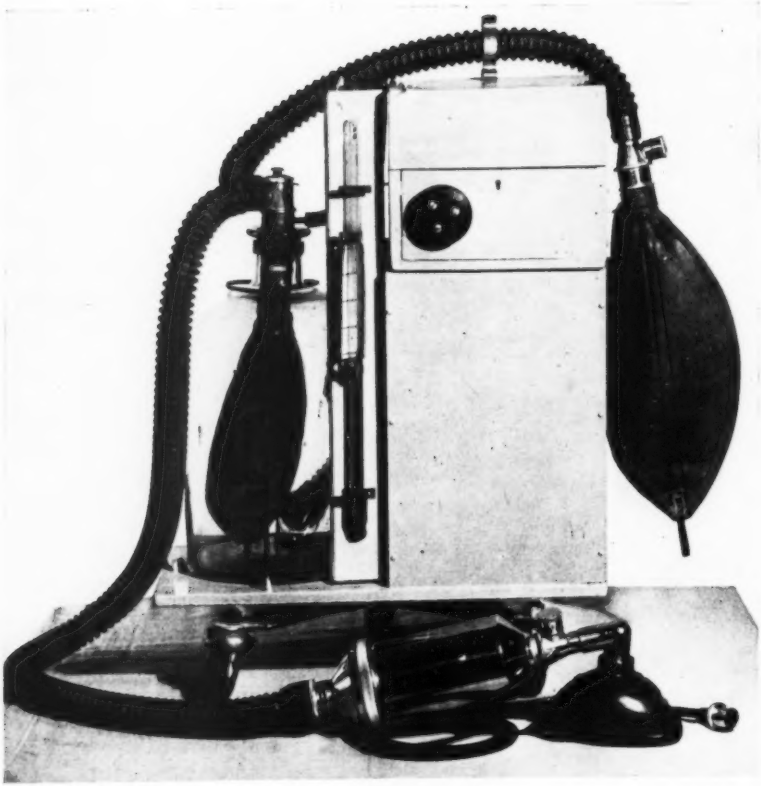

FIG. 8
The Aintree Respirator.

chest and abdomen. She was successfully respired by the machine during pericardectomy and did well after operation.

If at any time there is doubt as to what is happening in the lung, a change is made to hand control and further information sought by "palpating" the bag. On occasion the change is made as a precautionary measure, e.g. before incision of the pleura, or during the initial handling of the lung.

RELIABILITY

The machine has not been modified in any major way since it was first put into use, and apart from renewal of the breathing bags and the replacement of a broken manometer tube, it has needed little attention. Its mechanism can stand up to more abuse than might be expected.

Figure 8 is a photograph of the prototype machine of which a commercial model is being produced by Messrs. Medical and Industrial Equipment Ltd., London.

I wish to express my thanks to Mr. B. J. Bickford, Mr. Ronald Edwards, Dr. T. C. Gray, Dr. John Halton, the late Mr. A. M. Mair, Dr. O. F. Thomas, and Dr. G. Jackson Rees, without whose help and encouragement the machine would not have been produced.

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THREE-IN-ONE ANÆSTHETIC ASSEMBLY

By J. R. ESPLEN
Liverpool Thoracic Surgical Centre

THE THREE-IN-ONE assembly has been designed to provide an anæsthetic apparatus which is portable, adaptable, and easily sterilized.

It is essentially a Magill re-breathing attachment, modified to give the anæsthetist the choice of three alternatives and readily interchangeable 'circuits'.

The modifications, and the various methods of using the apparatus, are shown in the accompanying figures.

Note.—When using the semi-open continuous flow 'circuit' for induction purposes, depth of anæsthesia is more rapidly obtained if the expiratory valve on the bag mount is used instead of the valve nearest to the face-piece.

Once the desired depth of anæsthesia has been reached, and the patient has been levelled off, anæsthesia can be maintained by the absorption technique or by Ayre's 'T' piece method.

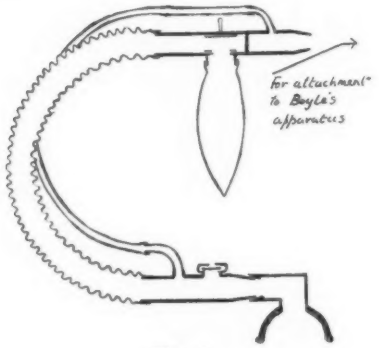

FIG. 1
A standard type of Magill rebreathing attachment.

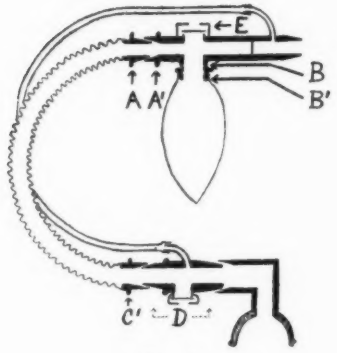

FIG. 2

The modified Magill rebreathing attachment.

A and B. Male unions. (Diameter and taper as for Waters' canister connections).

A′ B′ and C′. Female Unions.

D. Waters' canister expiratory valve and feed mount.

E. Expiratory valve fitted in place of ' on and off ' tap on bag mount.

The figure shows the apparatus assembled for use with the semi-open continuous flow technique, with partial rebreathing.

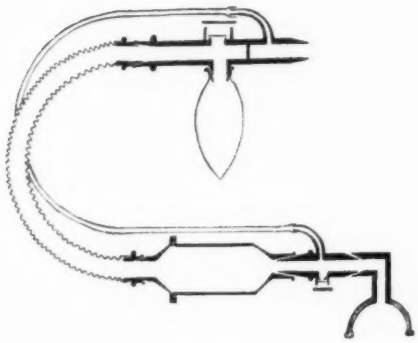

FIG. 3

Assembly for the to-and-fro absorption technique.
(The breathing bag may be attached directly to the canister or to the end (A) of the corrugated tubing if desired.)

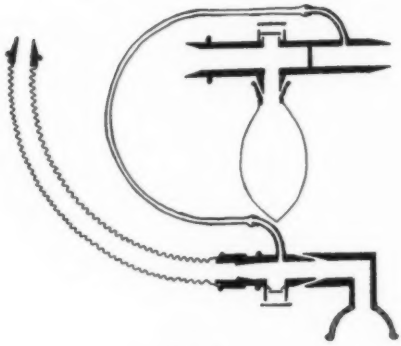

FIG. 4

The apparatus assembled for Ayre's 'T' piece technique

REVIEWS

Prostatectomy—A Method and its Management. By CHARLES WELLS. Published by E. and S. Livingstone Ltd. 24*s*. Pp. 103, 72 illustrations.

CHARLES WELLS in this book has shown how fast is the progress of surgery. It is twelve years since Wilson Hey began his work on "Aseptic Prostatectomy", seven years since he published it; Wells has realized its full implications and now he has produced this slim monograph which the reviewer thinks will prove to be epoch-making in the bewildering turmoil and confusion of the story of prostatectomy For many years surgeons have been wallowing in urinary stinks, bladder washouts, phosphatic crusts, and an appalling mortality. Asepsis, hæmostasis, the realization that the catheter is a lethal weapon *before* a prostatectomy, gave him a firm foundation on which to build his "superstructure"—technical, chemical, and biochemical. Of course others have advanced on other lines but none so far as he.

The reviewer must needs consider Wilson Hey's work as well as the advances made by the author, but no prostatectomist needs more than this clear, concise and—perhaps to our delight—very dogmatic work on transvesical enucleation of the prostate.

After these pæons of praise, criticisms. Since his and his staff's mortality is only 3 per cent it is ungenerous to continue; but of the six deaths half were associated with thrombosis, and nowadays thrombosis after prostatectomy should almost be a thing of the past. The writer considers that general anæsthesia (thiopentone) is responsible. The spinal analgesia should not reach a point

higher than half-way between the pubis and the umbilicus: voluntary inversion of the feet should be present throughout the operation. A patient must co-operate both during and after the operation. Then there will be no fall in blood-pressure, the sequela of which are the commonest causes of death after prostatectomy. A fall of blood-pressure in an old man, with little resilience in his vascular system, produces symptoms that we all know; also renal shock, as shown by a rising blood-urea and falling off of urine; and also thrombosis, cerebral, pulmonary and in the lower limbs, coming on perhaps ten days afterwards. The steep anti-Trendelenburg position, after the requisite height is reached (with heavy cinchocaine) is not used often enough by the anæsthetist. Many of us have used a single dose of Methedrine in every case of prostatectomy since it came on the market without ever seeing mental disturbances. Spinal anæsthesia, however, does require sympathetic and psychological understanding. Gelfoam (Upjohn) with oxycel gauze will enable the operation to be ended earlier but has led to trouble after. Indeed oxycel has necessitated later operations for the removal of calculi.

The simpler the operation the better. If prostatectomy is to be safe it must be so simple as to be available for all. But a professorial unit has unusual power and assistance. These adjuncts of prostatic-bed packing and intravenous transfusion let the surgeon off lightly. They are his soporifics. They permit him to complete inefficiently his hæmostasis by his diathermy hæmostat. There is no mention here of continous tap water per rectum.

The greatest of the many contributions that the author has made to prostatic surgery is that five quarts a day must be transfused into patients with failing kidneys. Wells said at his last meeting that "the treatment of the patient begins after prostatectomy", and in this book, particu-

larly the chapters dealing with fluids, electrolytes, and proteins, he proves his point.

The number of post-operative supra-pubic leaks is a little disturbing, but he does not use the necessary three layers, the last Lembert stitch. It is unnecessary to do his vasostomy: a crushing of the vas with a ligature round the crushed portion has sufficed to prevent epididymitis in more than 1,500 cases.

The illustrations, the argument, and the language are splendid.

Time will probably show that enucleation is not good enough if cancer of the prostate is to be avoided. Enucleation leaves the cancer-producing area behind: it saves lives but recks not of the distant future. The pelvic cellular tissues can be left bare with impunity with his aseptic procedure. He must go outside the capsule and do a subtotal prostatectomy if cancer, even years later, is to be avoided; but this more extensive operation is unsuitable for the worst cases.

His investigations into the rapid insensitivity produced by the use of streptomycin have been proved sound in forty-eight hours of intensive dosage. But surely it is better to make a Pearl Harbour attack with every known antibiotic before the battle—the prostatectomy—begins, not to await ascending infection from pyelonephritis.

Osteitis pubis has never occurred in his practice—nor after more than 2,000 other aseptic prostatectomies; it has occurred in 0.8 per cent to 18 per cent of cases after *non-aseptic* operations.

The 9 o'clock and 3 o'clock incisions, so successful in his treatment of Marion's disease, with resection of the internal sphincter, are necessary because of his incomplete resection of the trigone. Urethral strictures or constrictions

result from leaving the indwelling catheter for more than twenty-four to forty-eight hours.

The atonic or chronically distended bladder can be emptied by bi-manual pressure, assisted if necessary by the *post-operative* catheter.

But after all these criticisms, this is the best book we have had on prostatectomy. It shows that the operation is still in its infancy, that the anæsthetist and the biochemist play as great a part as the surgeon—until the biochemist can do without all of us.

Medical Annual 1952. Edited by SIR HENRY TIDY and DR. RENDLE SHORT. Published by John Wright and Sons Ltd., Bristol. Pp. 476, 51 illustrations. Price 25*s*.

THIS year's Medical Annual is much larger than the 1951 edition, 424 pages as against 366. It is difficult to imagine that the G.P. could find a better method of keeping up to date than the purchase and perusal of this publication. The practitioner's index of recent pharmaceutical and dietetic preparations, etc., at the end is a valuable addition. It should be noted that the information in it is supplied by the makers. The section of anæsthetics summarizing those aspects of the subject which have been in the minds of anæsthetists during the year is done by Dr. Langton Hewer with his accustomed ability.

FACULTY OF ANÆSTHETISTS

A MEETING of the Board of Faculty of Anæsthetists was held at the Royal College of Surgeons of England on the June 18th, 1952.

Dr. Bernard Johnson was elected Dean and Dr. Cecil Gray was elected Vice-Dean of the Faculty.

Dr. C. F. Hadfield was appointed Frederic Hewitt Lecturer for 1952. The Lecture will be given on Thursday, November 6th, the day of the Annual General Meeting of the Association of Anæsthetists.

Professor E. A. Pask was appointed Joseph Clover Lecturer for 1953.

NO ANÆSTHETIST IN ETHIOPIA

THE Ministry of Health, on behalf of the Government of Ethiopia, is looking for an anæsthetist for the Princess Tsahai Hospital in Addis Ababa. The salary offered is £2,100 per annum, tax free, for a three-year contract.

At present there is no qualified anæsthetist in Ethiopia and an experienced man is badly needed both for the hospital itself and to give instruction in other hospitals. The latter activity is particularly important in view of the role which the hospital is to play as the nucleus of a medical faculty for the future Ethiopian University.

The Hospital, which was opened last year, was built in memory of Princess Tsahai from private subscriptions in this country and Ethiopia. It is the only British-run hospital in Ethiopia, being entirely staffed by British doctors and nurses.

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